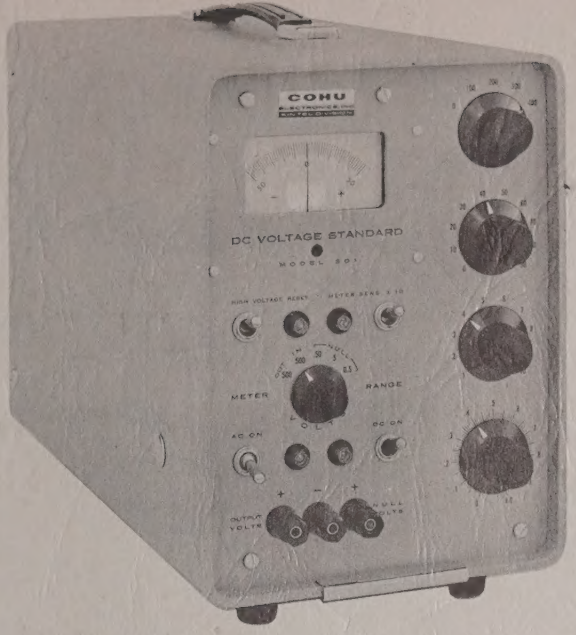

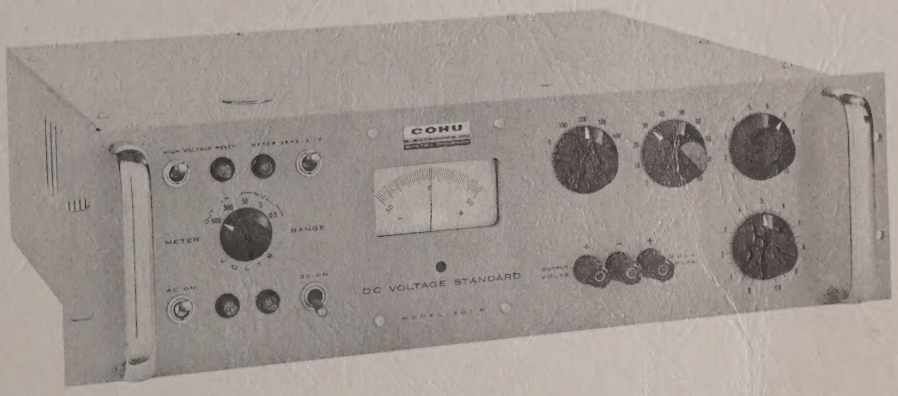

OPERATING AND MAINTENANCE
INSTRUCTIONS FOR

DC VOLTAGE STANDARD AND NULLMETER

MODEL 301 AND MODEL 301R

5725 KEARNY VILLA ROAD • SAN DIEGO 12, CALIFORNIA • PHONE 277-6700, AREA CODE 714

COHU
ELECTRONICS, INC
KINTEL DIVISION

MANUAL PRICE $10.00

Technical Manual
Code No. 15X-10

OPERATING AND MAINTENANCE INSTRUCTIONS FOR MODEL 301 DC VOLTAGE STANDARD AND NULLMETER

SERIAL NUMBERS 0001 THROUGH 3885
FSN 6625-793-1341

MODEL 301R

SERIAL NUMBERS 0001 THROUGH 1345
FSN 6625-819-0212 & 6130-894-1863

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15 FEBRUARY 1964

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Section I
GENERAL DESCRIPTION

1-1 INTRODUCTION

1-2. The ideal voltage standard for all practical applications must offer many features in combination: Good calibrated accuracy and resolution; efficient AC regulation to provide dynamic response; provision for internal nulling to yield accurate measurement of unknown voltages; and output current capabilities which would -- in effect -- make it a power supply providing reliable, standard DC voltages for the most critical applications.

1-3 IDENTIFICATION

1-4. The KIN TEL Model 301 is an extremely compact variable DC standard and null voltmeter. Direct-reading calibrated dials permit instant selection from voltages of standard-cell accuracy. (A chopper-stabilized circuit constantly compares the output with an internal standard cell to insure accuracy and stability.)

NOTE

For clarity, the designation Model 301 -- as used in this manual -- shall be applicable to the Model 301R as well, unless otherwise stated.

1-5. For null metering, the Model 301 accurately measures voltages from 1 volt to 501 volts through 4 decaded nullmeter ranges (50 millivolts to 50 volts full-scale deflection). (Dial settings provide a choice of 50V, 5V, or 0.5V, and the closing of a special switch changes sensitivity to allow multiplication of any range by a factor of 10).

1-6. The meter may also be used to indicate the input voltage to the unit or the output voltage of the supply.

1-7 PHYSICAL DETAILS

1-8. The Model 301 (Figure 1-1) is a compact, portable unit in a rugged crackle-finished metal case of hand-carry design. The front panel of the unit forms one end of the housing, and the rear panel forms the opposing end.

1-9. All controls, indicators, and terminals are located on the front panel for maximum convenience in operation. Four direct-reading controls optimize speed and accuracy of range selection. The meter is recessed for protection and minimization of surface glare.

Figure 1-1. Model 301 DC Voltage Standard and Nullmeter

1-10. The rear panel (Figure 1-2) contains the ventilation exhaust grille and the extractor-type fuse receptacle, as well as egress for the line cord.

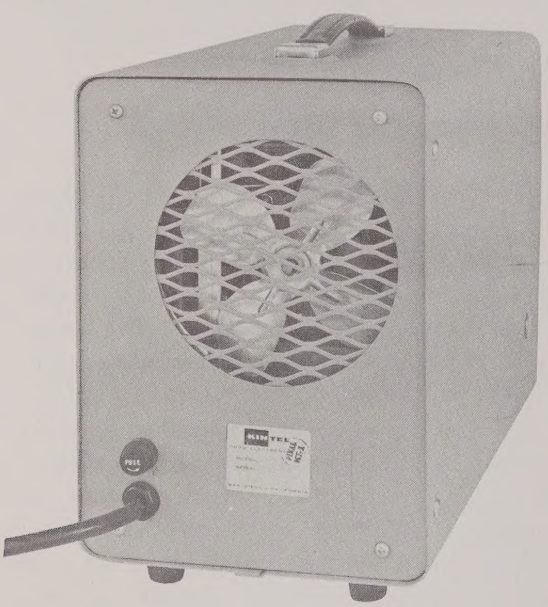


Figure 1-2. Rear of Model 301

1-11. MODEL 301R. The Model 301R (Figure 1-3) is electrically identical to the Model 301, but is physically designed to be mounted in a standard 19-inch rack cabinet, where it occupies an approximate 5-7/32 inches of vertical space.

1-12. Controls, indicators and terminals are located on the front panel as with the cabinet model, with differences in placement for optimum convenience and layout design. The ventilation also differs in that the warm air is exhausted through louvers on the chassis side panels.

1-13. The rear of the Model 301R (Figure 1-4) provides egress for the AC line cord and mounting space for the extractable fuse.

1-14 APPLICATIONS

1-15. The Model 301 is a versatile precision reference for calibration and measurement laboratories. It is particularly suited for production calibration of precision measuring instruments and power supplies.

1-16. It serves as a secondary voltage standard, a secondary voltmeter standard, or a transducer supply with equal precision and dependability. It is invaluable in the design of DC amplifiers and complex electronic circuitry and in the testing of transistors. It is an ideal computer refer-

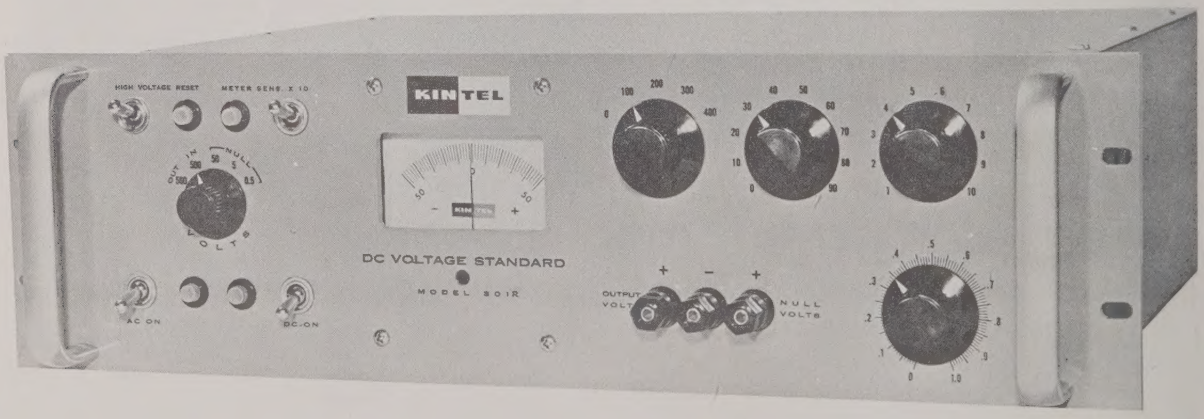


Figure 1-3. Model 301R (Rackmountable) DC Voltage Standard and Nullmeter

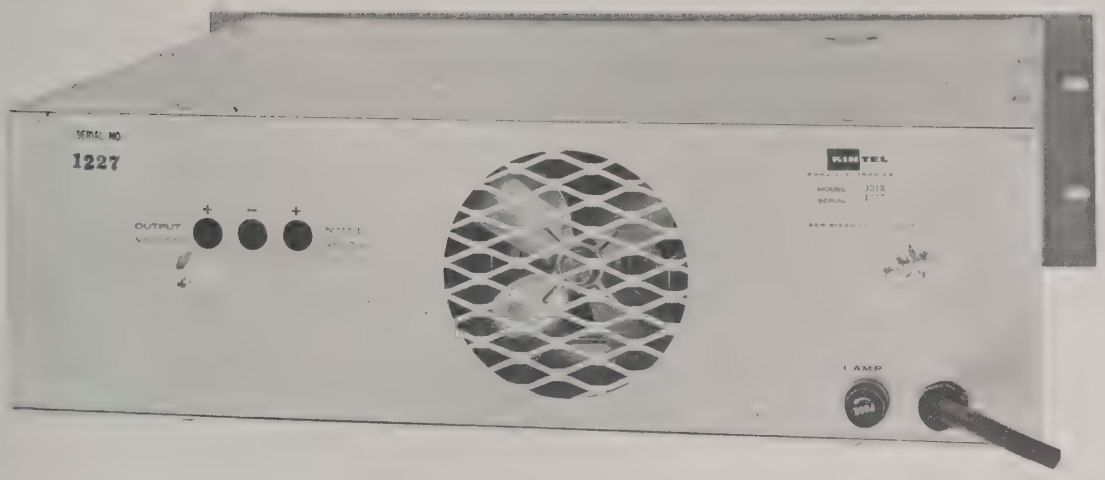


Figure 1-4. Rear of Model 301R DC Voltage Standard and Nullmeter

ence, most especially for such installations as require a precision reference which may be varied without loss of accuracy. The Model 301 also has a very definite place in the field of vacuum tube research and production.

1-17 OUTLINES AND DIMENSIONS

1-18. The physical dimensions and outlines of both the Model 301 and the Model 301R are shown in Figure 1-5 for convenience in plotting installation layouts. When making such plans, however, Section II of this manual should be studied for additional reference.

1-19 SPECIFICATIONS

1-20. Table 1-1 lists performance specifications of the Model 301. For additional electrical characteristics, refer to the details given in Section III of this manual.

1-21. Tabulation of such physical data as is not contained in Figure 1-5 will also be found in Table 1-1. Internal mechanics and other physical characteristics not externally discernible may be clarified by reference to Section IV of this manual.

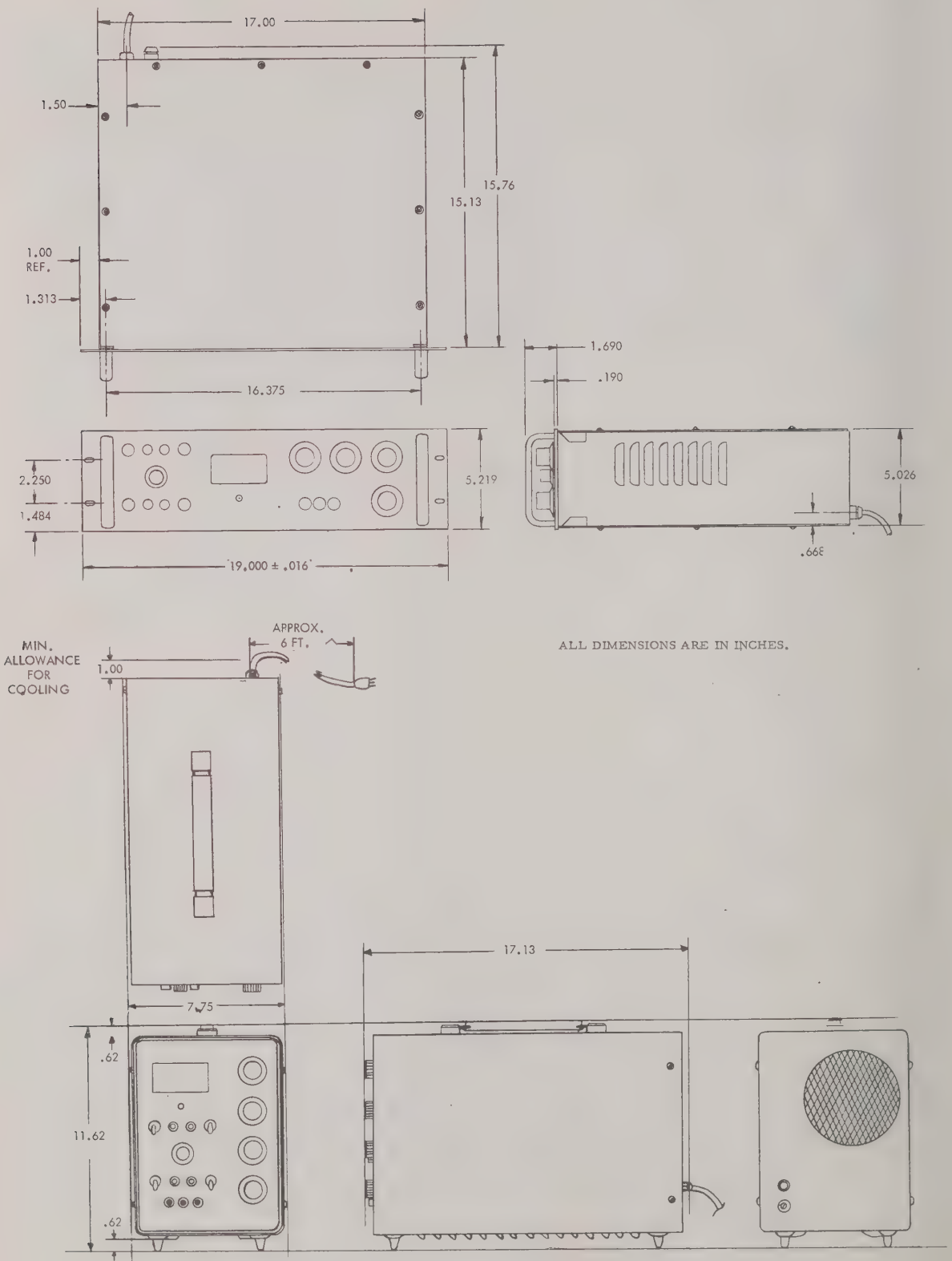


Figure 1-5. Outlines and Dimensions: Models 301 and 301R

Table 1-1. Specifications: Model 301 DC Voltage Standard and Nullmeter

OUTPUT VOLTAGE	1.00 to 501 volts; variable in 100, 10 and 1 volt steps; between one volt steps with a potentiometer
OUTPUT CURRENT	0 to 20 ma
METER RANGES, FULL SCALE (ZERO CENTER)	
DC OUTPUT OF 301	±500, 50* volts
EXTERNAL DC INPUT	±500, 50* volts
DC NULL METER	±50, 5, 0.5, 0.05* volts

*(These ranges are obtained by setting METER RANGE switch to 500 or 0.5 position and depressing METER SENS X10 switch.)

LONG-TERM STABILITY	±100 parts per million
SHORT-TERM STABILITY (SEVERAL HOURS)	±50 parts per million
OUTPUT VOLTAGE CALIBRATION	±0.02% or 2 mv
OUTPUT HUM AND NOISE	< 100 μv RMS
LOAD REGULATION	0.002% or 200 μv, whichever is greater, no load to full load
LINE REGULATION	0.002% for 10% line voltage change
METER ACCURACY	4% of full scale
SOURCE IMPEDANCE	< (0.01 or 0.001E_{out}) ohm, whichever is greater
FLOATING OUTPUT	> 1000 Mohms resistance between either output terminal and chassis ground. < 4 μA 60 cps and 0.5 μA DC current between either output terminal and chassis ground
RESPONSE TIME	0.2 millisecond
POWER REQUIREMENTS	105-125 or 210-250, 50-60 cps, 90 VA
DIMENSIONS	Model 301: 11" H x 7" W x 16-1/2" D Model 301R: 5-1/4" H x 19" W x 15-1/8" D
WEIGHT	Model 301: 29 lb net, 41 lb shipping Model 301R: 31 lb net, 45 lb shipping

KIN TEL reserves the right to change specifications without notice.

Section II
OPERATION

2-1 UNPACKING

2-2. KIN TEL DC Voltage Standards, Models 301 and 301R, are packed in sturdy corrugated paper cartons and are padded with shock panels of the same material. Damage will not be likely under average shipping conditions. It is important, however, to inspect thoroughly an instrument for visible damage immediately upon receipt of the shipment. Following a visual inspection, the unit should be given a performance test to check for shipping damage of a less apparent nature. (Refer to paragraph 2-11.)

2-3. In the event that damage is incurred in shipment, claim should be filed immediately with the delivering carrier, stating the extent of damage.

2-4 INSTALLATION NOTES

2-5. TEMPERATURE CONSIDERATIONS. The Model 301 employs as a reference a standard cell which is sensitive to temperature extremes. Essentially, ambient temperatures should be restricted to a range of 4°C (39°F) to 40°C (104°F).

2-6. POSITIONING CONSIDERATIONS. Standard cells are sensitive to extreme changes in physical position. After shipment or servicing during which the unit has been physically inverted, optimum performance will be achieved only after the instrument has been in operating position for several hours. For this reason, upon initial receipt of the unit or after lengthy storage, a warmup period of several hours is advised. The time required for this stabilization will vary with ambient temperature changes and the length of time the unit has been inverted physically, but will rarely exceed eight hours.

2-7 SETTING UP

2-8. Basic installation requirements are simple and straightforward for both the Model 301 and the Model 301R. The latter will be mounted in its standard rack as with any instrument (Figure 2-1); the cabinet model will be placed on the workbench or other

Figure 2-1. Model 301R in a Rackmount Installation

area where it is to be operated (Figure 2-2). In either case, a minimum of one inch should be allowed between housing and adjacent obstacles to provide adequate ventilation.

2-9. After the instrument has been installed properly in its operating position, ascertain that both the AC-ON and DC-ON switches are in the off position. The line cord may then be connected to a nominal 117-volt 60-cycle source.

2-10 INITIAL TESTING

2-11. As stated previously, a performance test should be made to discover any hidden damage which may have occurred during shipment. Although stringent tests are not possible without the equipment listed in Section III of this manual, a simple check of function without regard to accuracy may be made by following the procedure for using the Model 301 as a DC standard with any suitable DC voltmeter connected to the output terminals.

2-12. Note that while any reasonably zeroed DC metering instrument may be employed for simple functional checks to reveal damages, few commercial measurement devices are sufficiently accurate for significant testing of the Model 301. Conversely, the Model 301 furnishes an extremely accurate check of any DC measurement device.

2-13 OPERATING PROCEDURE

2-14. FOR USE AS A DC STANDARD. After executing the steps outlined in paragraph 2-9, the following procedure is used to employ the Model 301 as a DC standard (see Figure 2-3):

a. Set the METER RANGE switch to the OUT position.

b. Adjust attenuator switches to total 100 volts (100's dial at "0", 10's dial at "90", 1's dial at "9", and .1's dial at "1.0") or (100's dial at "0", 10's dial at "90", 1's dial at "10", and .1's dial at "0").

c. Switch on AC (AC-ON switch to ON position). The AC-ON pilot lamp will light to indicate that AC is being applied to the unit,

Figure 2-2. Model 301 on Production Test Bench

and the blower fan will operate, but no DC output will be available at the output terminals.

d. Allow approximately 15 seconds for circuits to warm to operating temperature, whereupon the HIGH VOLTAGE RESET indicator lamp will light.

e. Close the HIGH VOLTAGE RESET switch, extinguishing the lamp; allow the switch to spring back to its normally open position. At the moment the lamp is extinguished, the meter will register the 100-volt output.

f. Close the DC-ON switch. The 100-volt signal is now available at the output terminals.

Figure 2-3. Model 301 Controls

g. Selection from the possible attenuator dial setting combinations will provide any output from 1 volt to 501 volts. Operating procedure will be the same for all voltages.

2-15. METER SENSITIVITY. As indicated by dial markings, the meter sensitivity -- when used to indicate input or output voltages -- is 500 volts full-scale deflection. To obtain more sensitive readings, close the METER SENS X10 switch.

CAUTION

The METER SENS X10 switch should not be closed until it is ascertained that the voltage being measured DOES NOT EXCEED 50V (one major or five minor scale divisions).

2-16. Switch closure will be confirmed by immediate lighting of the METER SENS X10 indicator lamp. In cases which involve extended closure of this spring-return switch, pressure may be inadvertently relaxed. The moment contact is broken, the lamp will be extinguished as a warning to increase pressure for switch closure.

2-17. FOR USE AS A NULLMETER. To employ the Model 301 as a DC nullmeter, proceed as follows:

a. It is assumed that steps outlined in paragraph 2-9 have been executed.

b. Set the METER RANGE switch to the IN position.

c. Connect the unknown voltage to the input terminals (+NULL

VOLTS and "-") and close the DC-ON switch. The meter will indicate the amount of applied voltage within 4%. To determine the absolute value of the input voltage, it must be internally nulled with the output of the standard supply.

d. Set the attenuator to the approximate voltage indicated by the meter; set the METER RANGE switch in the NULL 50 position. Meter will now indicate the approximate difference between the input voltage and the attenuator setting.

e. Adjust attenuator dials as required to reduce the voltage-difference indication to a center-scale position.

f. As zero (or null) indication is approached, increase meter sensitivity by use of the METER RANGE and METER SENS X10 switches, and by continued resetting of the attenuator dials, until absolute zero (scale center) is reached.

g. The final reading of the attenuator dials will reveal the exact value of the voltage being applied to the input terminals.

2-18 CALIBRATION

2-19. Calibration of the Model 301 is not considered as maintenance. It is generally considered both unnecessary and undesirable to recalibrate the instrument in the field. If a 301 should fail to meet specifications, it is recommended that the instrument be returned to the factory for checking. Such recommendation does not imply that calibration procedures are too complex or exacting for the equipment or personnel of any complete standards laboratory, but rather that unexplained departures from specifications are evidence of an anomaly which should be located and corrected to avoid future malfunction.

2-20. In the event that calibration must be checked away from the factory, a listing of required equipment and procedures are included here.

2-21. CALIBRATION EQUIPMENT. The following items are required for calibration of the Model 301 :

1. AC voltmeter such as Hewlett-Packard Model 400D
2. Oscilloscope such as Hewlett-Packard Model 130A
3. Leeds & Northrup Voltbox #7591
4. Leeds & Northrup K3 Pot # 7553, with Standard Cell and auxiliary 2V wet cell
5. Electronic Galvanometer, Kin Tel Model 204A or 204AR
6. Source of variable line voltage such as General Radio Model W5 with 0-2A AC ammeter and 0-150V AC voltmeter
7. Resistor, 50 ohms, 5%, 5W
8. Resistor, 25K ohms, 5%, 10W
9. Six-inch test lead with test clips

2-22. CALIBRATION PROCEDURE. Calibration equipment is set up as shown in Figure 2-4. The output of the AC voltmeter is used to drive the scope input, providing waveform observation, and the galvanometer is connected for null observation. It is assumed that the 301 to be calibrated is operating normally, and that output noise at any voltage setting is less than 100 microvolts.

2-23. The following procedure is recommended :

a. Disconnect the line cord of the 301 from the AC outlet and remove the instrument from its case.

b. Ground the negative terminal to the front panel; connect the line cord to the Variac outlet, switch AC on at the Variac and the 301 and allow the unit to warm for thirty minutes, with Variac set to provide 115 volts AC.

c. Set Voltbox and K3 Pot to measure 500.000 volts.

d. Set 301 METER RANGE switch to OUT, switch DC on, and set dials to provide a 500-volt output.

e. Adjust R180 (see Figure 2-5) as required to bring 301 output to precisely 500.000 volts.

f. Connect the AC voltmeter to the junction of CR101/CR102 and negative ground (Figure 2-6) and adjust R138 for minimum noise as displayed on the oscilloscope.

g. Reconnect the AC voltmeter to the output terminals of the Model 301; this connection will be maintained for the balance of the calibration procedure to provide constant observation of noise on the scope.

NOTE

After each adjustment of the Model 301, allow one second (approximately) for the unit to settle before measuring noise.

h. Observe the noise present at the output. This must be less than 100 microvolts and typically is approximately 20 microvolts of 60-cycle noise and harmonics.

i. Adjust Variac to drop line voltage to 105V; check voltage output. A normal reading will be within 5 millivolts of 500 volts as set by the dials in step "d" above.

j. Adjust Variac to raise line voltage to 125V; again check output to insure that it is within 5 millivolts of the 500-volt setting.

k. Return Variac setting to 115 volts. Open the DC-ON switch of the Model 301 to remove voltage from the output terminals; connect a 25,000-ohm 10-watt resistor across the output terminals to impose a 20-milliampere load.

l. Close the DC-ON switch and check the output to insure that it is within 5 millivolts of 500 volts. Open the DC-ON switch and remove the resistor from the output terminals. Close the DC-ON switch.

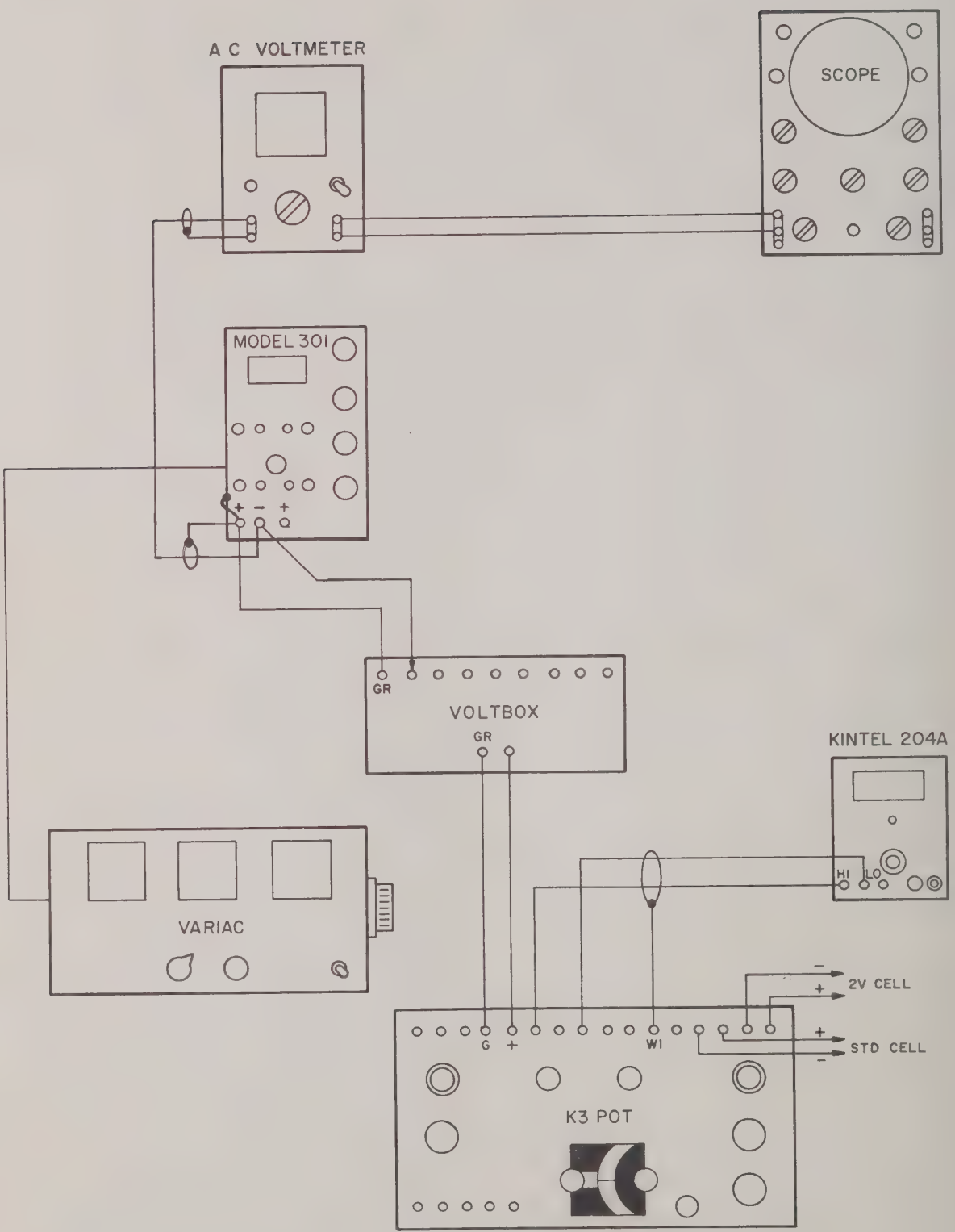


Figure 2-4. Equipment Connections for Model 301 Calibration

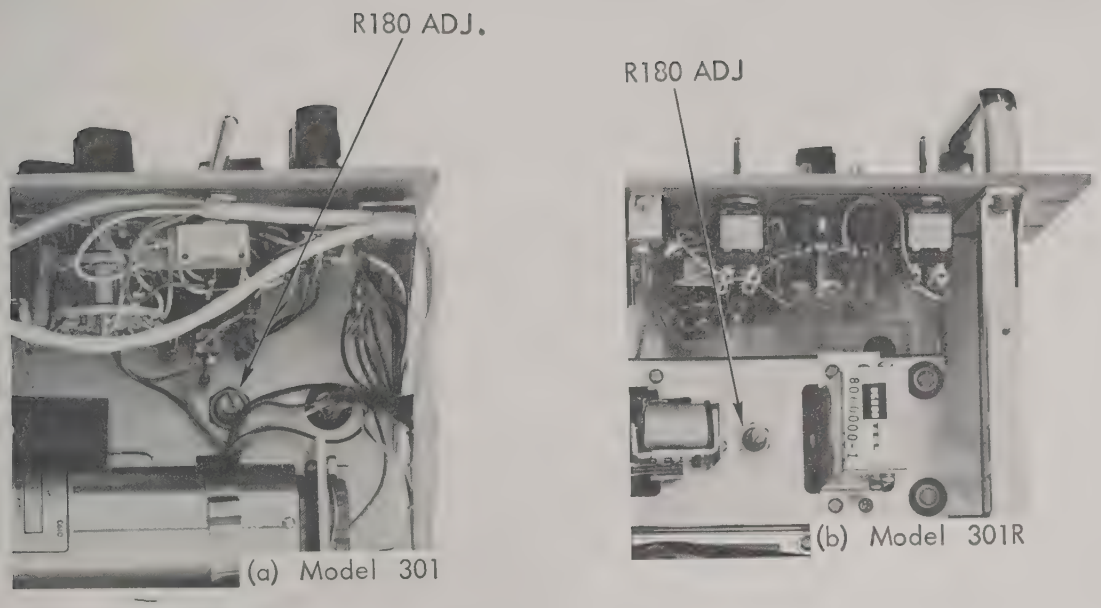


Figure 2-5. Calibration Adjustment (R180)

m. Set the dials of the Model 301 to provide a 1-volt output; adjust the test instruments for the 1-volt measurement. Output should be well within 2 millivolts of the set output without adjusting R180.

n. Repeat steps "k" and "l" above, this time using a 50-ohm 5-watt resistor in place of the 25K, 10W.

o. After removal of the 50-ohm load resistor, adjust the Model 301 to deliver 10 volts and adjust test instruments to measure the 10-volt output. Reading should be within 2 millivolts of 10-volt setting.

p. Advance the 0-1-volt control of the Model 301 to the 1-volt position. Output should measure 11 volts minimum.

q. Return 0-1-volt potentiometer to the 0-volt position. Measure the output of the Model 301 with dials set at 20V; repeat measurement at 100V, 200V, 300V, 400V and 500V settings.

r. The ground lead to the front panel may be removed from the negative output terminal and connected to the positive output terminal, and any or all of the above checks may be repeated without adjusting R180. This will reveal any offset between grounded positive and grounded negative conditions; this offset normally is barely perceptible.

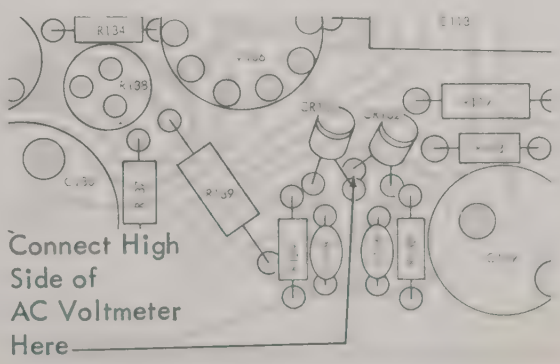


Figure 2-6. Minimum Noise Adjustment (R138)

s. Switch off line voltage, remove test connections and return the Model 301 to its case.

t. Reconnect 301 to test equipment; spot checks may be made to insure that performance is the same as when uncased.

NOTE

If the 301 has been physically inverted during the process of returning it to its case, it may take several hours to settle (refer to paragraph 2-6).

Section III
THEORY OF OPERATION

3-1 INTRODUCTION

3-2. The KIN TEL Model 301 DC Voltage Standard and Nullmeter is an electronic precision instrument of compound design. It incorporates features of modern electronic circuitry such as are found in DC amplifiers, power supplies and voltmeters. Each circuit function embodies elements of theory and attendant mathematical formulae peculiar to its own design.

3-3. It will not be a purpose of this manual to enter into the fundamental mathematics of these circuits. The prime consideration will be an outline of the actual functions performed and -- where deemed advisable -- practical examples which may be used to familiarize the operator with the logic and pattern of such functions.

3-4 OVERALL FUNCTION

3-5. Figure 3-1 illustrates basic configuration of the power supply elements in the Model 301.

3-6. As shown in the block diagram, the positive output terminal of the supply is directly connected to circuit common. Thus the output potential is controlled by the adjustment of the attenuator, which varies the negative end of the supply with respect to circuit common.

3-7. The high voltage supply is capable of delivering 700 volts to the passing tube, which may in turn deliver as much as 500 volts to the output terminals.

3-8. If the attenuator is set to provide maximum output, the resistance shown in Figure 3-1 as R_1 will have a

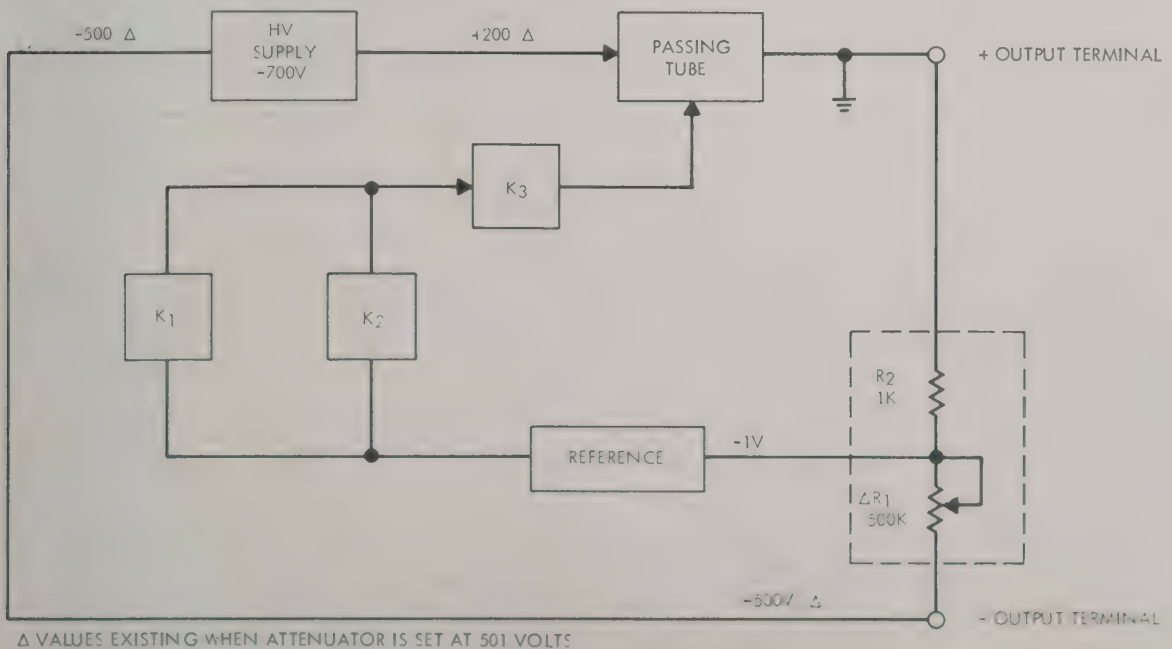


Figure 3-1. Basic Circuit Configuration of Model 301

value of 500K. R_2 will always have a value of 1K. Thus the total output will be 501 volts.

3-9. The 1-volt signal developed across R_2 is compared to the reference voltage. This precise reference is obtained from a standard cell in conjunction with a precision divider and a mercury cell.

3-10. Any difference between the precision 1-volt reference and the signal across the 1K section of the attenuator is applied to the chopper amplifier (K_1 in Figure 3-1). High frequency components of the output/attenuator signal are applied to the wideband amplifier (K_2). The outputs of these stages are applied to the DC output amplifier (K_3). The output signal from K_3 is applied to the passing tube, conduction of which is controlled by this signal.

3-11. As an example, if the attenuator dials are set to total 501 volts, there must be an approximate 200V drop across the passing tube (based on the 700 volts available from the high-voltage supply). If the setting is decreased to 400 volts, the drop across the 1K resistor obviously will increase, with a resulting difference between the reference signal and this voltage. As described in paragraph 3-10, this difference signal will result in an increase in bias applied to the grid of the passing tube, decreasing its conduction.

3-12. The proportional increase in voltage drop across the passing tube will effect a corresponding decrease in the voltage across the output terminals, with a resulting decrease in voltage across the 1K resistor. With the re-establishment of a balance between this voltage and the reference signal, no further change will be effected in passing tube-grid bias, and the output of the Model 301 is precisely as selected by the attenuator.

3-13 DETAILED BLOCK DIAGRAM

3-14. The block diagram presented in Figure 3-2 illustrates detailed circuit configuration of the Model 301.

3-15. Functional identification of major components is simplified by the inclusion of their respective circuit symbols in the blocks with which they are associated. Operating continuity is more easily followed by the incorporation of signal path indications as well as DC distribution.

3-16. The difference signal referred to in paragraphs 3-10 and 3-11 is applied to the chopper amplifier, which acts only upon the DC and very-low-frequency information in the difference signal; consequently, the chopper amplifier output consists of amplified DC and low frequency components superimposed on the carrier signal created through the modulating action of the chopper. The demodulator removes the carrier frequency from this amplified signal.

3-17. The wideband amplifier acts upon only the high-frequency components of the output/attenuator signal. Output of the wideband amplifier thus consists of amplified high frequency signals.

3-18. Outputs of both wideband amplifier and (after demodulation) chopper amplifier are applied to the DC output amplifier.

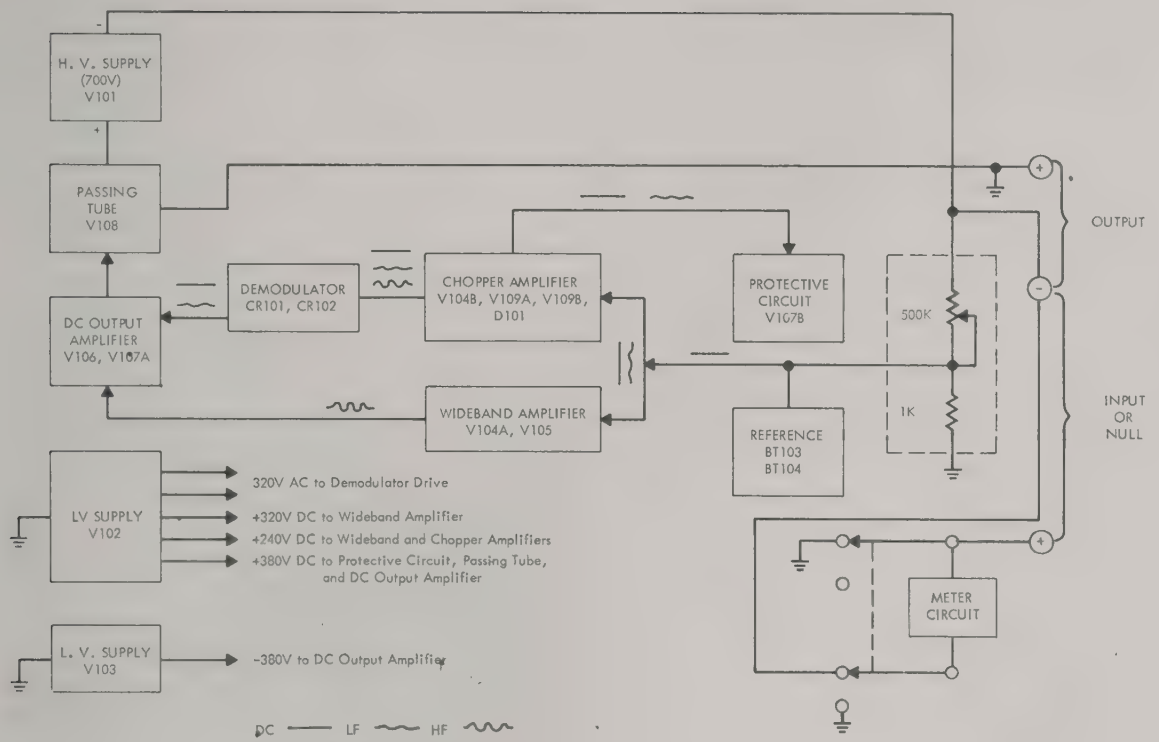


Figure 3-2. Detailed Block Diagram of Model 301

3-19. Two separate low voltage supplies are depicted in Figure 3-2 (connections to these are here omitted to facilitate tracing of signal paths). One of these supplies furnishes +380 volts to the protective circuit, the passing tube, and the DC output amplifier; +320 volts to the wideband amplifier; +240 volts to wideband and chopper amplifiers; and 320 volts AC to drive the diode network in the demodulator. The other supply shown provides -380 volts for the DC output amplifier. Thus the DC output amplifier is operated between +380 volts and -380 volts.

3-20. The protective circuit opens the plate circuit of the passing tube whenever the output exceeds the voltage set by the attenuator.

3-21. The meter circuit includes -- besides the meter movement itself -- a diode protective network and the required selection of multipliers mounted on the meter range switch. The switch is depicted in Figure 3-2 as a DPDT type to facilitate diagram simplification.

3-22 CIRCUIT DETAILS

3-23. Occasional reference to Figure 3-2 may serve to familiarize the reader with block relationships within the overall circuitry of the Model 301. However, it is suggested that the details in the following paragraphs will be more readily assimilated if the continuity is followed on the schematic diagram in the back of this manual; the drawing may be unfolded and extended to full view without removal from the binding.

3-24. REFERENCE. The accuracy of the Model 301 as a voltage standard is determined by the accuracy of its internal reference. which consists of standard cell BT103, mercury cell BT104, and a precision divider formed by R179, R180, and R181. See Figure 3-3.

3-25. The mercury cell, potentiometer and resistors are arranged to furnish a bucking voltage -- adjustable by R180 to a very fine accuracy -- which opposes the nominal standard cell output, resulting in a precise 1-volt signal for use as a reference.

3-26. The voltage developed across the 1K resistor (R302) is compared to the 1-volt reference signal. Any difference signal resulting from the comparison is automatically applied to the chopper amplifier. Note that a signal path to the chopper amplifier exists only when relay K103 is energized, and that K103 is energized only when manual closure of S102 has energized relay K101. Figure 3-4 illustrates operating sequence of the involved switch and relays.

3-27. CHOPPER AMPLIFIER. As shown in Figure 3-5, the chopper amplifier mainly consists of the chopper (D101) and three amplifier stages (V104B, V109A, and V109B).

3-28. Basically, the chopper* is an oscillating reed which vibrates at a frequency determined by the application of a nominal voltage to the chopper drive coil. Contacts at either end of the oscillation path are connected and disconnected at the predetermined frequency. Thus a DC

* Recommended reference: "Chopper Checkout Procedure for KIN TEL Equipment" (Publication Code No. 13-57).

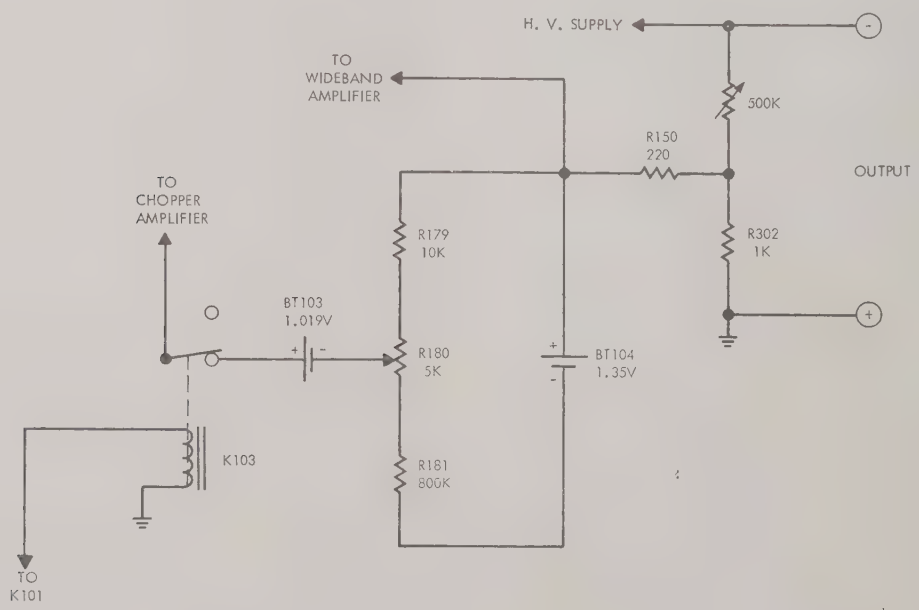
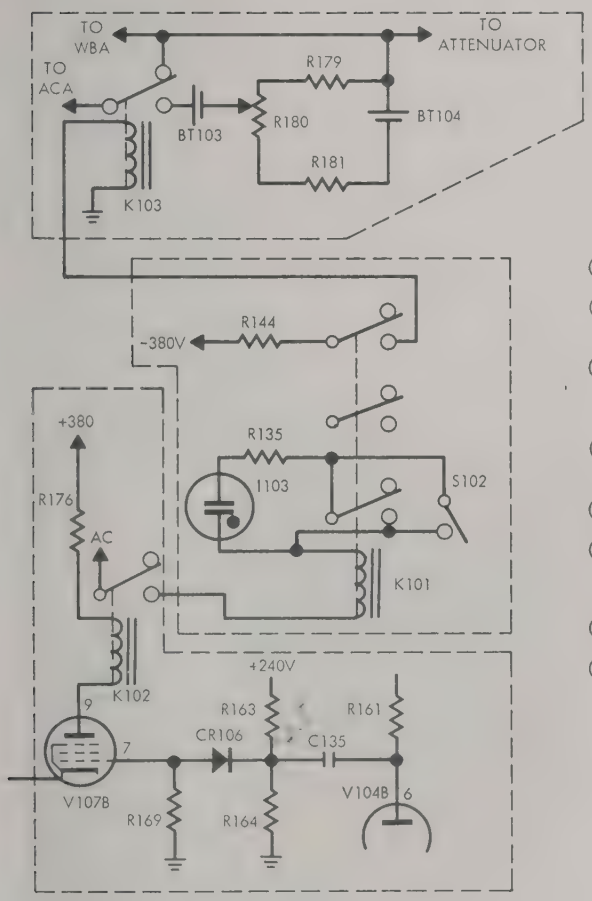


Figure 3-3. Reference Circuit Configuration (DC-ON and HV RESET Switches both Closed at Moment of Consideration)



RELAY SEQUENCE

1. As heater current is applied, V107B conducts current through K102.
2. K102 becomes energized, thus applying AC to one side of K101 drive coil and lighting HV Reset indicator.
3. When HV Reset Switch S102 is closed, K101 drive coil is energized and remains so with its self-holding contacts after S102 is allowed to open.
4. The closing of one set of K101 contacts applies a negative DC voltage to K103 drive coil.
5. The energizing of K103 applies the standard-cell voltage to the ACA.
6. If the signal at V104B plate contains negative excursions of great enough amplitude (See Section 3.2.6), CR106 conduction cuts off V107B, and K102 is thus de-energized.
7. Opening of K102 de-energizes K101.
8. Opening of K101 de-energizes K103, the opening of which eliminates the standard-cell input to the ACA.

Figure 3-4. Relay Operating Sequence

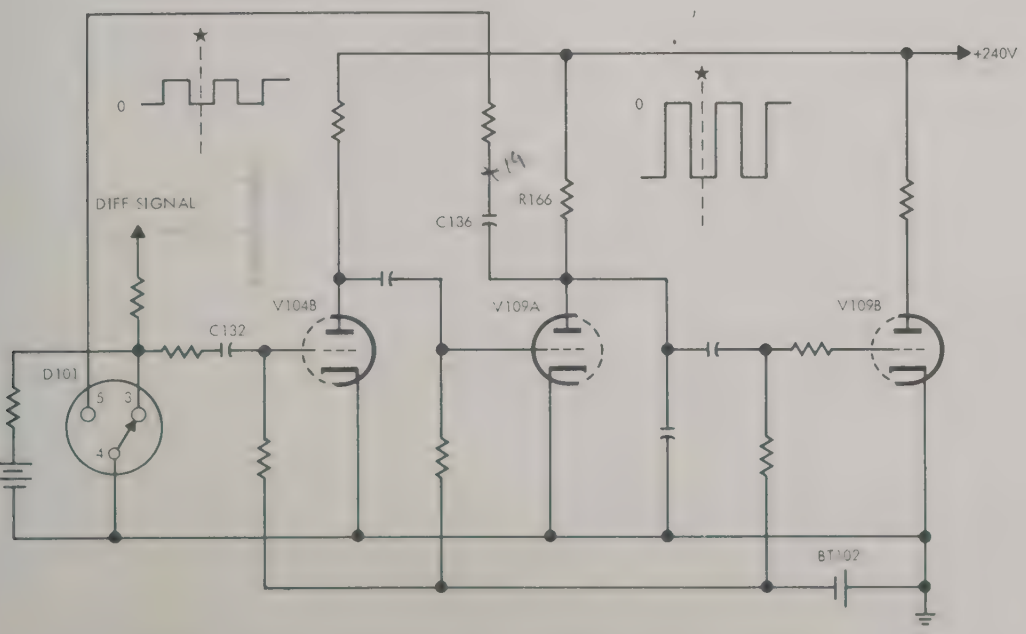


Figure 3-5. Chopper Amplifier Configuration

signal applied to one contact may be "grounded" each half-cycle, converting the originally smooth potential into a pulsating DC signal. The quality choppers employed by KIN TEL in the Model 301 furnish a precise 60-cps signal (due to their 60-cps drive voltage), having a square-topped waveform as shown in Figure 3-5.

3-29. The 60-cps signal from the chopper is amplified in a capacitance-coupled circuit which removes any reference to ground, changing the pulsating DC to AC. The output of V109A is in phase with the input signal to V104B. However, the output signal from V109A (coupled by C136) is grounded by the chopper reed on alternate excursions, thus the amplified signal is tied to ground at the top (if input signal polarity is as shown; in the case of a negative input signal, the output waveform from V109A would be tied to ground at the bottom).

3-30. As shown in Figure 3-5, output capacitor C136 is shorted to ground when the input grid is open, and input capacitor C132 is shorted to ground when the output plate is open. At the moment of consideration, no DC is applied to C132. With no input signal, there is of course no output signal at the plate of V109A (C136 remains essentially charged to the V109A no-signal plate voltage, and has an extremely slow discharge path through the output circuit while the chopper reed is at pin 3).

3-31. Assume the V109A no-signal plate voltage (to which C136 charges) to be 75 volts; assume further that a positive DC signal (represented in Figure 3-5 as a battery with a current-limiting resistor) is applied to the chopper amplifier: With the reed at pin 3, input is grounded, and no signal reaches the amplifier. With the reed at pin 5, the signal reaches the amplifier with the following results: V104B grid swings positive, V104B plate becomes less positive, V109A grid becomes negative, and V109A plate swings positive.

3-32. Assume that V109A plate goes from 75 volts to 85 volts: With the reed at pin 5, C136 is grounded and quickly charges to the higher V109A plate voltage of 85 volts through R166, but no voltage is coupled to the output (now grounded). When the reed swings to pin 3, input is grounded, V109A plate voltage decreases to its no-signal value of 75 volts and V109A output is ungrounded. Since C126 is now charged to 85 volts and has no quick-discharge path, the decrease in plate voltage is coupled to the output, changing it from 0 volts to -10 volts. It can be stated, then, that the output voltage equals the V109A no-signal plate voltage (75 volts with chopper reed at pin 3) minus the V109A signal plate voltage (85 volts with reed at pin 5) 75 volts minus 85 volts equals -10 volts. This formula prevails regardless of the polarity of the amplifier input signal.

3-33. For example, with a negative input to the amplifier, V109A plate voltage would have been lower (assume 65 volts) at the moments when the chopper reed was at pin 5, and C136 would have discharged quickly through R159 and the output chopper to this value. Again, the output equals the V109A no-signal plate voltage (85 volts with chopper reed at pin 3) minus the V109A signal plate voltage (65 volts with chopper reed at pin 5): 75 volts minus 65 volts equals +10 volts.

3-34. In recapitulation, it is apparent that chopper action serves to tie the output wave to ground so that a useful DC may be obtained. When the input signal is positive as in Figure 3-5, the chopper ties the top of the output waveform to ground, providing a negative, pulsating-DC output. With a negative input signal, the chopper ties the bottom of the output waveform to ground, resulting in a positive, pulsating-DC output.

3-35. A study of the schematic diagram will reveal that a difference signal (resulting from the comparison of the reference voltage with the signal across R302) will be applied through a voltage divider (R154 and R156) and an RC network (R155/C131) to pin 3 of the chopper.

3-36. Diode CR105 limits the input voltage to the chopper to a maximum 0.3 volts. This limiting factor prevents opening of the output circuit by the over-voltage protective circuit at V109B when the unit is first turned on. At this time, the error voltage is equal to the reference voltage (1.0V) but of the opposite polarity to that which would obtain in the event of an over-voltage condition.

3-37. The signal applied to pin 3 of the chopper is converted to pulsating DC at a 60-cps rate. When this pulsed signal is applied to C132, the AC component is coupled to the grid (pin 7) of V104B, where it is amplified, then coupled through C134 to the grid (pin 2) of V109A. From the plate (pin 3) of V109A, the amplified signal is coupled through C137 and R168 to grid-pin 7 of V109B, the plate of which tube is coupled by C114 to the driven-diode demodulator.

3-38. A portion of the signal at the output of V109A is applied to pin 5 of the chopper through C136 and R159; the resulting signal is applied to the control-grid circuit of V105, where it serves to stabilize the wideband amplifier and improve over-load recovery time.

3-39. DEMODULATOR. Diodes CR101 and CR102 are arranged in a circuit which provides properly phased demodulation of the chopper amplifier output signal. Figure 3-6 illustrates the basic configuration of the demodulator circuit.

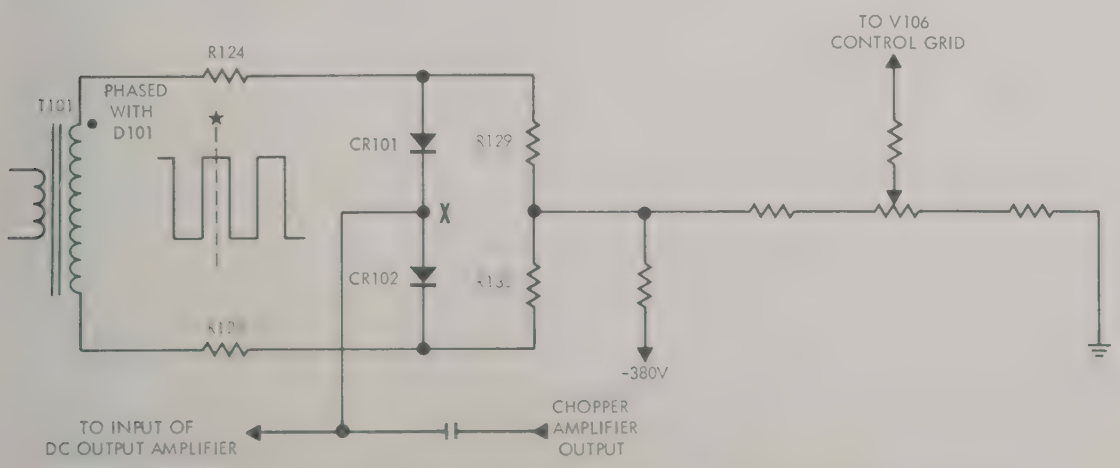


Figure 3-6. Demodulator Circuit Configuration (Simplified)

3-40. The diodes are arranged essentially as a keyed clamp circuit. At the half cycle under consideration, the diodes conduct; the diode junction (X) is then at the same approximate potential as the junction of R129 and R130 (plus the normal DC drop across these resistors resulting from current produced by the return of this circuit to the -380V potential). The waveform is thus clamped to the reference point at the moment indicated by the dotted line and asterisk. Reference of this circuit to a high negative potential provides the simplest means of effecting proper negative bias for V108 grid, permitting it to be driven by V106B plate signals. In addition, the reference network includes a divider which is precisely tapped to provide an extended negative bias for the pentode control grid.

3-41. The demodulated chopper amplifier output signal is applied through R123 to the grid of the triode section of V106 (first stage in the DC output amplifier).

3-42. WIDEBAND AMPLIFIER. High frequency components of the output/attenuator signal are applied through C105, R109, and an RC network (R110 and C106) which provides large-signal compensation, to the grid of V104A, first stage in the wideband amplifier. The lower frequency limit of this amplifier is approximately 1.5 cps.

3-43. The amplified signal is coupled from V104A through C109 and an overload compensation network (R115 and C111) to the grid of V105. This grid circuit includes another network through which is injected the chopper-demodulated signal which increases stabilization of the wideband amplifier.

3-44. Under overload conditions, excessive intermediate injection is made at the grid circuit of V105 to facilitate rapid recovery of the wideband amplifier. As overload occurs -- occasioned by instrument turn-on or other source of rapid transients -- the intermediately injected signal at this network energizes neon bulb I102, reducing the effective resistance between chopper-pin 5 and grid-pin 1 of V105, thus increasing the injection applied to counteract the overload condition.

3-45. The amplified signal from V105 is coupled through C113 to the grid (pin 2) of the triode section of V106, first stage in the DC output amplifier.

3-46. DC OUTPUT AMPLIFIER. Triode section V106A is a cathode follower operated between -380 volts and chassis ground. The signal developed across R128 is common to the cathode of the pentode section. After amplification, this signal is applied as feedback through R122 and C110 to the plate of V104A, thus controlling -- through feedback -- the general frequency response characteristics of the system.

3-47. The signal at the plate of V106B (amplified combination of wideband and chopper amplifier outputs) is applied directly to the control grid (pin 5) of passing tube V108. Note that this passing tube drive signal is paralleled by another signal from the wideband amplifier: V105 plate signal is coupled through C122 to the grid of V107A, and the output of this cathode follower is coupled through C123 to the control grid of the passing tube. Loading effect of cathode follower stage V107A serves to control the natural response roll-off which V106B

would otherwise display at higher frequencies. Additionally, the parallel signal path thus provided for driving the passing tube will pass high frequency components of the drive signal which may be beyond the response capabilities of V106.

3-48. In effect, V106B serves as a driver for the passing tube at DC and low frequencies, but as frequency increases, its gain diminishes until -- at unity gain -- the drive signal for the passing tube is applied directly by V107A. (See Figure 3-7.)

3-49. PASSING TUBE. The signal from the DC output amplifier which is applied to the grid (pin 5) of the passing tube (V108) varies its conduction. Thus it can be seen that an increase in the voltage developed across R302 will decrease conduction of V108. Since V108 is -- in effect -- connected in series between the positive output terminal and the positive side of the high voltage supply, the voltage drop across V108 will increase, with resulting decrease in available output voltage. A decrease in the voltage developed across R302 will effect a corresponding increase in V108 conduction and resultant increase in the available output voltage.

3-50. PROTECTIVE CIRCUITS. Although not shown in Figure 3-5, the over-voltage protective circuit may be seen in the vicinity of the chopper amplifier circuit shown in the foldout schematic diagram.

3-51. The output of V104B which is coupled to the grid (pin2) of V109A is also coupled through C135 to a voltage divider (R163/R164). The approximate +2.5 volts DC at this divider junction is applied to the cathode of

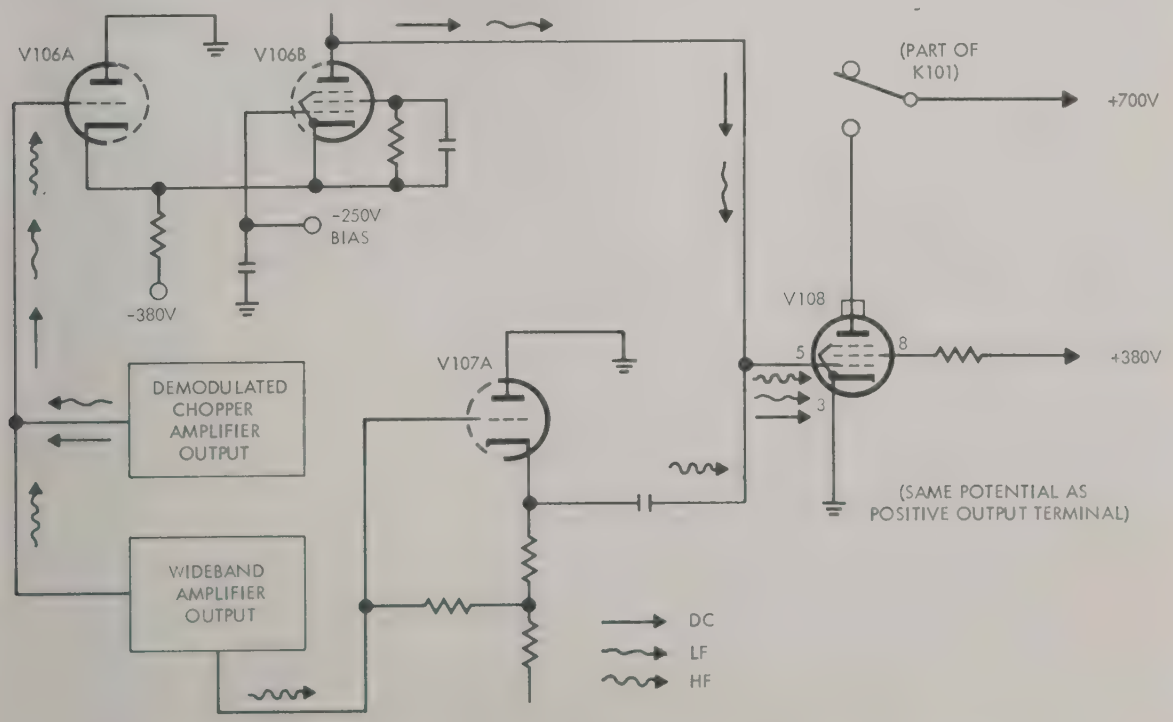


Figure 3-7. Configuration of Passing-Tube Drive and Output

CR106 as a holding voltage, rendering the diode non-conductive unless voltage coupled from V104B plate exceeds -2.5 volts.

3-52. It can be seen that sufficient negative voltage applied to pin 3 of the chopper will result in an AC signal output from V104B having such peak-to-peak amplitude that negative excursions will overcome the holding voltage of +2.5 volts and allow CR106 to conduct, which decreases the conduction of V107B. The decrease in V107B conduction permits the contacts of relay K102 to open, which de-energizes relays K101 and K103; consequently, the plate circuit opens in passing tube V108. Figure 3-4 illustrates the operating sequence of these relays.

3-53. It would appear that the application of a positive voltage to chopper pin 3 would have the same effect as in the case of a negative voltage, since the peak-to-peak amplitude of the resultant AC signal would contain negative excursions of proportionate value. This would mean that when RESET switch S102 is manually closed, the subsequent energizing of K103 would apply +1.0 volt to the chopper, with the result that the protective circuit would function and the reset relay would open almost the moment it had been closed.

3-54. For this reason, CR105 has been incorporated in a circuit at the input of the chopper amplifier. The application of a positive signal greater than +0.3 volt will cause CR105 to conduct, limiting the signal applied to the chopper.

3-55. Another circuit protection is incorporated in the form of a transistorized bias control for V107B. The pulses across R152 (4-ohm resistor in the filament-rectifier circuit for the wideband amplifier and first stage of the chopper amplifier) are filtered and applied as forward bias to Q101. In the event of filament burn-out in either V104 or V105, the load on the rectifiers (CR103, CR104) is reduced, resulting in a reduction of Q101 bias voltage. This allows the cathode of V107B to rise, de-energizing protective relay K102.

3-56. METERING CIRCUIT. The indicator used to meter the input, output, and null voltages is a 25-0-25 μa movement connected in series with R182, R183, R184, and R185. It is shunted by CR107 and CR108, two diodes which serve to protect the meter movement. Normal voltage across the meter is less than that required for diode conduction. If the meter circuit is overloaded, the diodes limit the voltage across the meter to a safe value.

3-57. The multiplier string is mounted on METER RANGE switch S104, adjustment of which determines meter resistance. SENS X 10 switch S103 -- when closed -- shunts one position of the multiplier string, effectively increasing the sensitivity of the meter by a factor of 10 (since it decreases meter resistance by a factor of 10).

3-58. ATTENUATOR. The attenuator consists of three switched sections and variable wire-wound resistor R301. One switched section is used for switching between 0 and 400 volts. This section consists of resistors R311 through R314. The second section (R307 through R310) is used for switching between 0 and 90 volts. The third section (R306 through R306) is used for switching between 1 and 10 volts.

3-59. In each section, provision is made for disabling protective relay K102 during the time the unit is being switched. This is accomplished by momentarily applying a positive voltage to the grid of V107B, insuring that K102 will remain closed for the moment of switching, thus preventing activation of the protective circuit while attenuation is being changed.

3-60. This momentary application of a positive voltage to V107B grid is provided through "dumping switch" action of the rear wafer and contact arm for each of the three switches. As indicated in Figure 3-8, the make-before-break switching action in these wafers provides this momentary positive voltage application when any attenuator switch is re-positioned.

3-61. As previously described, the attenuator is connected between the negative output terminal and chassis ground (positive output terminal) to provide control of the output voltage. Any change in attenuator setting will cause a corresponding change in the voltage drop across R302 (paragraphs 3-10, 11, 12). The difference between the voltage across R302 and the reference voltage (paragraph 3-26) is applied to the amplifier circuitry such that the passing tube is controlled to the point which provides the exact output determined by the changed attenuator setting.

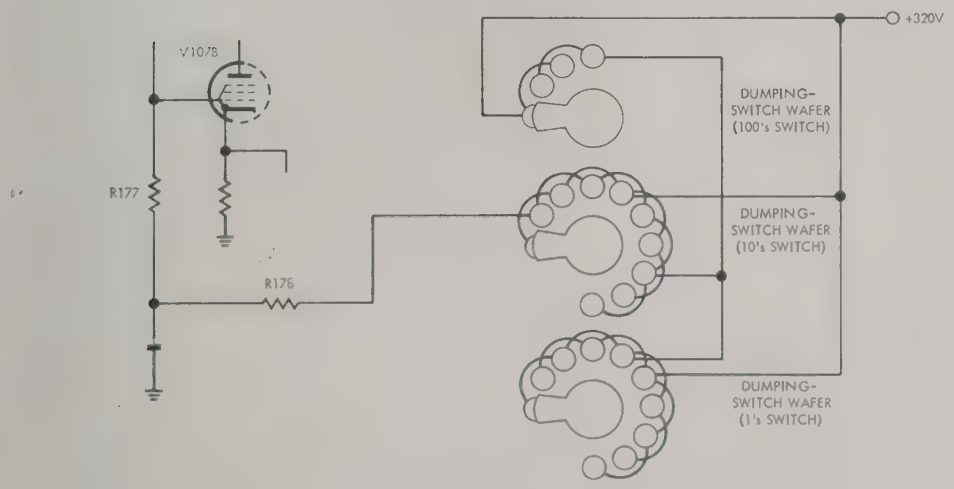


Figure 3-8. Switching Configuration of Attenuator Dumping Wafers

Section IV
MAINTENANCE

4-1 INTRODUCTION

4-2. The combination of precision circuit design and the planned application of quality components (used well within the component manufacturers' rated safety margins) serves to minimize, in the Model 301, the maintenance problems normally associated with electronic equipment. As with any precision instrument, certain prescribed procedures and precautions must be followed to insure maximum benefits from the precision of which the instrument is capable.

4-3. Only qualified, trained technicians should perform required maintenance. The intricacy of the precision circuits in the Model 301 is such that severe damage may result from repair activities attempted by untrained personnel.

WARNING

Due to the high potential of the floating chassis in the Model 301, LETHAL VOLTAGES may be encountered unless normal precautions are taken. Shock hazard may be reduced by connecting a clip lead from the positive output terminal to earth ground.

4-4 PREVENTIVE MAINTENANCE

4-5. GENERAL. Periodic cleaning and inspection should be scheduled to prevent the accumulation of dust, lint, or other airborne pollution which might be detrimental to operation. The use of forced-air cooling will engender such accumulation, since large amounts of the ambient atmosphere are forcibly drawn past the inner chassis of the instrument.

4-6. If the installation area is air conditioned, atmospheric pollution will be minimized; however, the cleaning of grilles, louvers, and inner surfaces of racks or cabinets -- as well as the instrument chassis -- should be scheduled after each approximate 2000 hours of operation until the optimum time lapse between cleanings can be determined by experienced observation.

4-7. FAN MOTOR LUBRICATION. The Model 301R is equipped with a fan motor which requires no lubrication or disassembly. The cabinet model, however, incorporates a motor which should be lubricated immediately following each cleaning operation. (See Figure 4-1.)

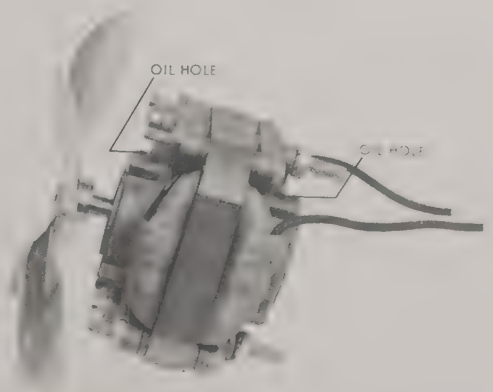


Figure 4-1. Blower Lubrication

4-8. It is extremely important that the proper lubricant (Shell Oil Co.'s Tellus No. 33) be used for this application. Since the bearings are of a porous material (to provide a predetermined rate of oil flow to the motor shaft), oils having a lacquer base may congeal as a result of heat generated by motor operation, thus forming a coagulant which would inhibit oil flow.

4-9. Clogged bearings will inevitably reduce motor speed -- perhaps to the point of intermittent operation. If this condition is not corrected (by following the procedure outlined in paragraphs 4-22 through 4-26) the motor may become completely inoperable, which would void the performance specifications for the instrument.

4-10. ETCHED BOARD HANDLING. Every precaution should be taken in handling etched circuitry while servicing. Boards may be contaminated by salts and acids present in the human skin (as well as by soldering fluxes other than pure rosin). Such contamination can lower leakage resistance between paths or components mounted on the boards. It is advisable to wear clean, cotton gloves when it becomes necessary to handle such circuitry.

4-11 CORRECTIVE MAINTENANCE

4-12. Procedures involving the removal and replacement of components mounted on etched boards must be executed with constant regard for thermal and mechanical considerations. The iron used to solder and unsolder connections should be kept at the lowest optimum temperature, and efficient heat sinks should be used wherever possible. It is definitely advantageous to use eutectic solder -- relatively inexpensive insurance for the etched boards and any components (especially semiconductors) which may be easily damaged by an overly hot iron.

4-13. As illustrated in Figure 4-2, component leads are crimped slightly before soldering. When a component is to be removed, clip the leads at a point near the component (which may then be discarded). Carefully heat the leads protruding from the board, simultaneously exerting a gentle pull on the crimped end from the etched side of the board (as illustrated in Figure 4-2). Note that the protruding leads are so cut (and straightened if necessary) that they present minimum resistance for withdrawal from the hole in which they are mounted. This insures that the least possible damage will be incurred by the epoxy board or its etched signal paths. Removal of large capacitor cans may be facilitated by lightly whisking off excess solder after applying heat to the tabs or prongs which secure it. Alternatively, special etched board de-soldering kits are commercially available.

4-14. VACUUM TUBES. Logically, vacuum tubes are prime suspects in any malfunctioning or inoperative instrument in which they are installed. Therefore, one of the first steps in troubleshooting the Model 301 should be the checking of voltage measurements (refer to paragraph 4-58).

4-15. One fact which must be emphasized is that the best of tube-testing equipment cannot provide true evaluation of a tube's worth as can the actual observation of that tube's performance in the precision circuits of the Model 301.

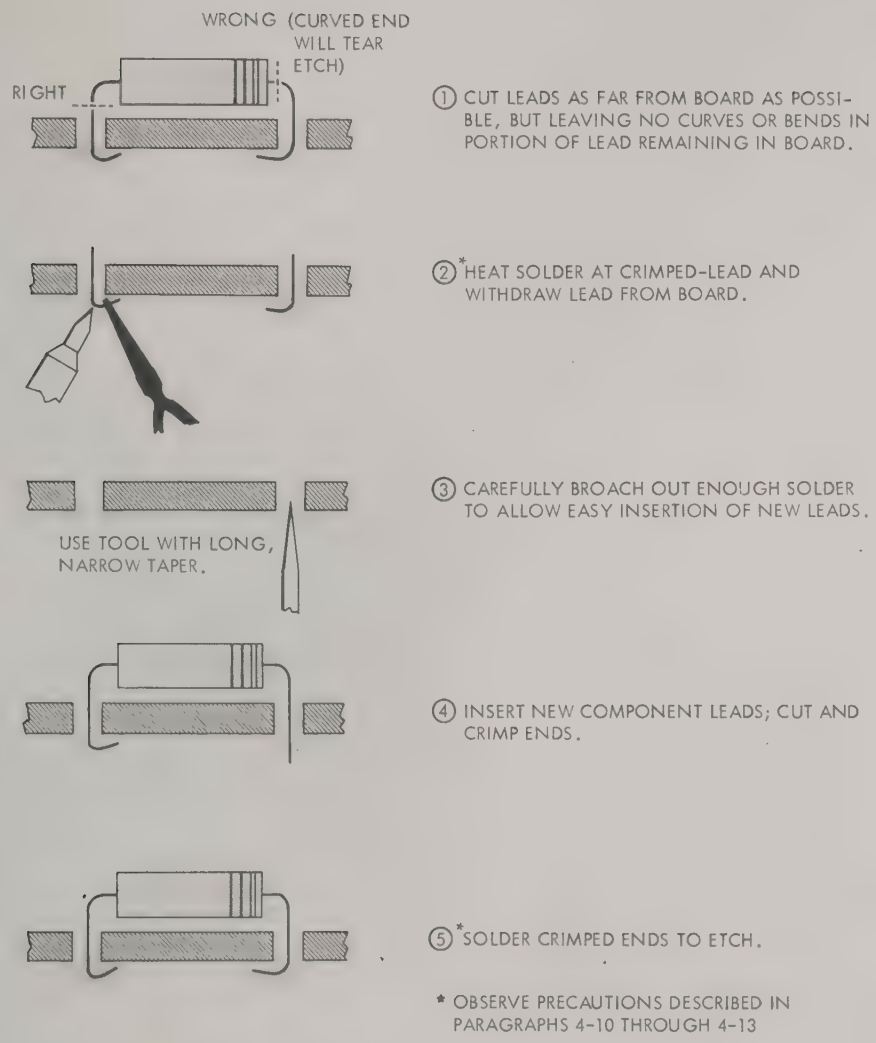

WRONG (CURVED END WILL TEAR ETCH)
RIGHT
① CUT LEADS AS FAR FROM BOARD AS POSSIBLE, BUT LEAVING NO CURVES OR BENDS IN PORTION OF LEAD REMAINING IN BOARD.
②*HEAT SOLDER AT CRIMPED-LEAD AND WITHDRAW LEAD FROM BOARD.
③ CAREFULLY BROACH OUT ENOUGH SOLDER TO ALLOW EASY INSERTION OF NEW LEADS.
USE TOOL WITH LONG, NARROW TAPER.
④ INSERT NEW COMPONENT LEADS; CUT AND CRIMP ENDS.
⑤*SOLDER CRIMPED ENDS TO ETCH.
* OBSERVE PRECAUTIONS DESCRIBED IN PARAGRAPHS 4-10 THROUGH 4-13

Figure 4-2. Replacing Components on Etched Boards

4-16. DIODES. Silicon diodes CR103 and CR104 may be tested by checking the 12-volt DC output (approximate) across 129A. CR101 and CR102 may be tested in the circuit by checking the approximate voltage (+10 and +34 volts respectively) across R129 and R130. CR105 and CR106 may be checked by substitution.

4-17. When one of a pair of diodes is suspected or proved anomalous, it is good policy to replace both. Where one diode is found to be shorted, the other will have incurred damage; if one diode is open, the characteristics of the remaining one will probably differ from those of a newly replaced mate. The safest practice is the replacement of paired diodes by a new pair.

4-18. CHOPPER. The only continuously moving part in the Model 301 is the chopper. When not subjected to severe or continuous overloads, the chopper may operate for an indefinite

period. Specifications which are most readily degraded by chopper troubles are those for output noise and for long-time and short-time stability. The only valid test of a chopper's performance is the substitution of a chopper known to be good.

4-19. For more detailed information on the nature and function of choppers, refer to KIN TEL Service Notes (Code No. 13-57): Chopper Checkout Procedure for KIN TEL Equipment.

4-20. RELAYS. Unlike the chopper, relays in the Model 301 are activated only at random intervals determined by specific operating requirements. Their maintenance consists of checking contact points and -- when needed -- burnishing the points to insure clean contact, and maintaining correct spring tension to insure proper relay drive response. If maintenance personnel are not trained or equipped to service relays of this type, temporary substitution of a good replacement spare will indicate whether this is the source of trouble, and if the replacement unit corrects the condition, it may be permanently installed.

4-21. BIAS CELLS. Periodic maintenance of the Model 301 should include a check of bias cell voltages. It is recommended that replacement be made for any cell which provides less than 1.3 volts. (Refer to paragraph 4-43.)

4-22. FAN MOTORS. As mentioned in paragraph 4-9, improper lubricants can clog fan-motor bearings in the cabinet model (Model 301), resulting in one of several conditions requiring cleaning of the mechanism. If this becomes necessary, the motor should be removed from the housing and disassembled as shown in the exploded view in Figure 4-3.

4-23. After the motor is disassembled, the bearings may be cleaned by lightly scraping the surfaces of each bearing to remove any hardened deposits and then soaking the entire bearing assembly in a solvent for at least four hours. A stiff brush dipped in the solvent may aid in removing deposits from the rotor shaft.

4-24. When soaking has sufficiently removed deposits on the bearings, all surfaces should be wiped dry with a clean, lint-free cloth. Ascertain that there is no deposit remaining before beginning re-lubrication.

WARNING

Certain solvents emit insidiously toxic vapors. BE SURE VENTILATION IS ADEQUATE FOR THE SOLVENT BEING USED.

4-25. After bearings are clean and dry, place the assembly in an oil bath, using only the recommended lubricant (Shell Oil Company's Tellus No. 33). Soak in the oil bath for two hours, remove from bath, and wipe off excess oil. The motor may then be reassembled, again using the exploded view in Figure 4-3 as a guide.

4-26. Care should be used in aligning the motor shaft and bearings before the four frame bolts are tightened. Since the bearings are semi-floating, no difficulty should be encountered in assembling them properly.

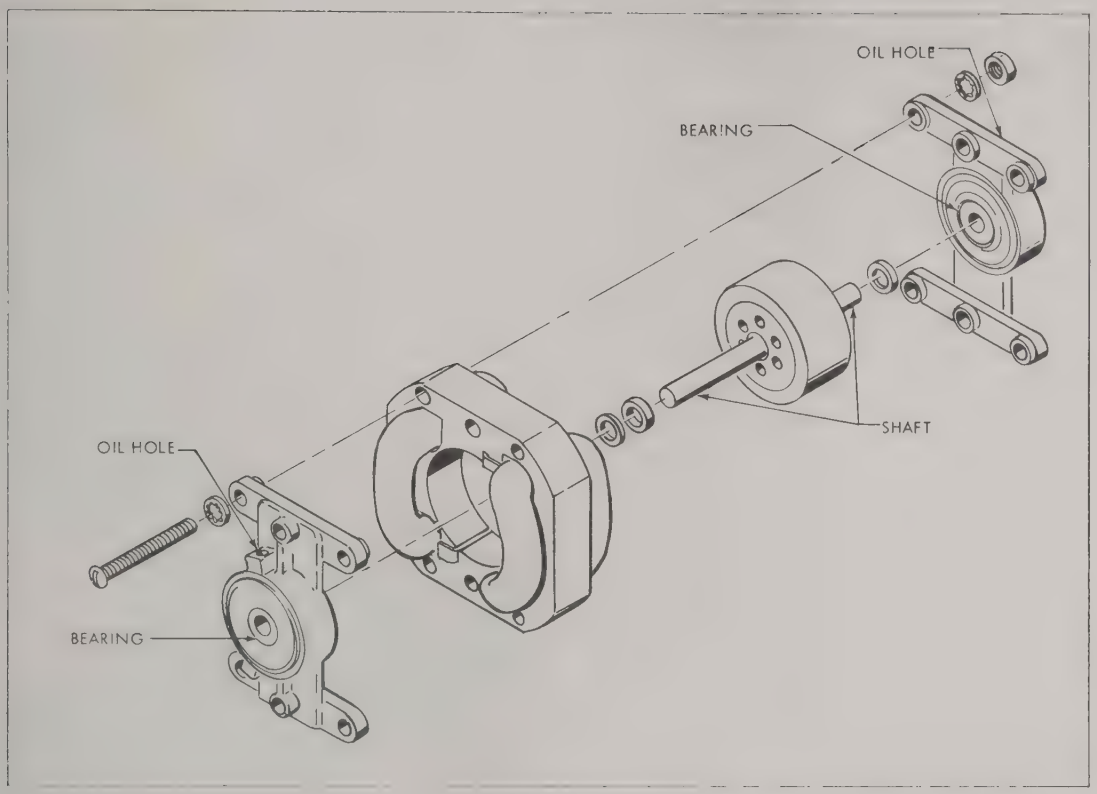


Figure 4-3. Exploded View of Blower Motor Used in Cabinet Model 301

4-27. Subsequent oiling should occur at regular intervals, length of which should be determined as stated in paragraph 4-7. Frequent removal of accumulated dust from the motor by means of compressed air is recommended; however, care should be exercised to avoid dust fallout over the instrument chassis.

4-28. METER CHECKOUT. If a meter becomes suspect, the output of the Model 301 should be checked on a meter of known accuracy. If the test meter reading differs from that of the meter in the Model 301, temporarily remove meter-diodes CR107 and CR108 to determine whether a defective diode may be causing the error.

4-29. If the meter reading is not changed by removal of the diodes from the circuit, a final test may be made to determine malfunction of the meter movement:

a. Disconnect meter from the circuit by removing the terminal wires; note polarity of connections during removal.

b. With a low voltage supply such as a flashlight cell and potentiometer (adjusted to the accuracy of the test meter), apply approximately 0.05 volts to the terminals of the suspected meter. The meter movement should indicate full scale with this voltage applied.

4-30. TROUBLE SHOOTING. Most troubles which could arise in the Model 301 would trigger the protective circuit. Relay operation is a basic func-

tion of the protective circuit; therefore, a prime requisite of the trouble shooter is a knowledge of the relay sequence illustrated in Figure 3-4 of this manual. Familiarity with these circuits will expedite the isolation of troubles, since the protective circuit may be operative before the relays will function according to design, and the relays must follow proper sequence to allow the operation of other circuits. Consequently, voltage measurements in most circuits are meaningless unless all relays remain closed.

4-31. If -- when the HIGH VOLTAGE RESET indicator lamp lights, and switch S102 is manually closed-- relay K101 closes momentarily but opens after S102 is allowed to open, one of several conditions may be indicated:

a. There is an open filament in V104 or V105 (or the associated DC power supply is defective), causing Q101 collector current to drop, with resulting decrease in plate current of V107B; or

b. V107B grid is held beyond cutoff by a high negative voltage across R169 -- a condition which could be caused by too great an input signal to V104B, resulting in excessive drive of CR106 and consequent decrease in V107B conduction; or

c. Chopper drive connections have become reversed.

4-32. If conditions exist as in "a" above, such will be apparent upon examination of the associated circuitry. If the source of trouble is as outlined in "c" above, simply reverse the leads to the chopper drive.

4-33. With conditions as described in "b" prevailing, further checks will be required. First short R160 (grid resistor for V104B), thus removing any input signal to the chopper amplifier; then close switch S102 to energize relay K101. Maintaining the short at R160, allows S102 to open. If K101 again becomes de-energized, look for trouble in the circuitry of V107B. If K101 remains closed while R160 is shorted, it must follow that an excessive difference signal is being developed between the standard cell circuit and the opposing voltage which appears across R302. The reasoning for this is that -- with R160 shorted -- no signal is applied to CR106; therefore, bias on V107B grid should remain normal or below cutoff level. After establishing normality of V107B circuitry, the short may be removed from R160.

4-34. If an excessive difference or correcting signal is suspected, measure the AC voltage at the junction of CR101 and CR102. The normal correcting voltage which the chopper amplifier applies at this point is 2.7 volts (RMS) and appears as illustrated in Figure 4-4. If this voltage is noticeably higher, the DC output amplifier is not responding to the applied signal.

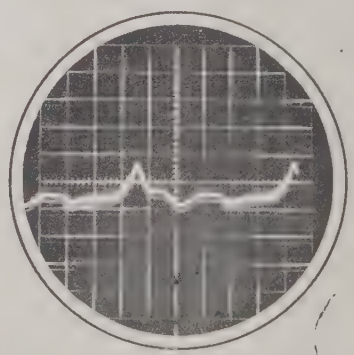


Figure 4-4. DC Balance at Junction of CR101/CR102

4-35. Open or intermittent circuits could result from physical abuse of the etched board. To locate such an open or intermittent circuit between tube pins and circuit paths on the board, tube socket adapters are recommended.

4-36 PART LIFE EXPECTANCIES

4-37. VACUUM TUBES. The tubes used in the Model 301 DC Voltage Standard and Nullmeter may reasonably be expected to operate satisfactorily for over 1000 hours (refer to Table 4-1). Satisfactory performance has been observed in many units having tubes two or three times the conservative ages shown in Table 4-1. There is no stated or implied recommendation that tubes -- or any other parts -- be changed at the end of the hours tabulated. Conversely, a 5751 amplifier tube (V104A/B) with 1000 hours of operation is preferable in the circuit to a new and untried 5751; acceptable tube transconductance is far more demonstrable by use on the circuit than by checking with any tube tester.

4-38. Tube failure at an age less than that shown in the table does not necessarily mean that associated circuit parts have changed value, but recurrent failure certainly warrants a check of all related components.

Table 4-1. Tube Life Expectancy

CIRCUIT SYMBOL	TUBE TYPE	LIFE (HOURS)
V101	5Y3GT	2000
V102	6X4	1000
V103	6X4	1000
V104	5751	3000
V105	6AU6	4000
V106	6AU8	1000
V107	6AU8	1000
V108	6BG6G	2000
V109	6AW8	1000

4-39. Vacuum tubes employed in the Model 301 are more subject to gradual deterioration than to abrupt failure. As the emission of one or more tubes degrades over a period of time, the gains of the various amplifiers undergo a commensurate loss -- ultimately to the point where new tubes are necessary.

4-40. DIODES. Although diodes used in the Model 301 are not likely to fail under normal operation, there exists the possibility of damage by excessive current as a result of circuit changes following the failure of other components. The same kind of damage might result from careless probing of the circuit. The remaining risks are over-heating from soldering tools (refer to paragraph 4-12) and accidental breakage of the diode case. Tests outlined in paragraph 4-16 will reveal any of these anomalies, and the rule given in paragraph 4-17 should be followed strictly to insure subsequent performance.

4-41. CHOPPER. As was stated in paragraph 4-18, choppers may operate for an indefinite period under favorable conditions. A general life expectancy of 10,000 hours of operation is perhaps an acceptable average for mechanical choppers. Under advantageous conditions, satisfactory performance frequently has been obtained for periods as long as 25,000 operating hours. It is recommended that only KIN TEL Model DCM-88A be used as a chopper replacement. Extreme changes in chopper characteristics could warrant the readjustment

of R180 to provide proper calibration. Refer to paragraph 2-18.

4-42. Due to the variations among choppers of different manufacture, it is recommended that technical personnel responsible for operation and maintenance of the Model 301 become familiar with the precision modulators which furnish the chopping action. Reference is made to KIN TEL Service Notes (Code No. 13-57) entitled "Chopper Checkout Procedure for KIN TEL Equipment."

4-43. BIAS CELLS. Due to the negligible current drain on the mercury cells (BT101, BT102, and BT104) used for bias voltages in the Model 301, operational life of the cells should be the same as their normal shelf life (approximately two years). Characteristically, these cells remain at full potential (1.35 volts) until just before complete failure. Any cell measuring 1.3 volts or less (as read by a vacuum tube voltmeter connected directly across the cell) should be immediately replaced.

4-44. RELAYS. Under normal conditions, and with proper maintenance, relays should last indefinitely. The lack of maintenance or imposition of undesirable operating conditions will commensurately reduce the life of relays necessitating replacement.

4-45. MISCELLANEOUS PARTS. Application will largely determine the life expectancies for switches, resistors, capacitors, coils, or transformers. Depending on the values and individual characteristics of these components, and the applied voltages and current flowing through them, useful lives may range from long to very long. As a generalization, resistors are expected to last longer than coils and transformers, which in turn usually outlast capacitors. Small capacitors are customarily used longer than large electrolytic units. In the Model 301, values and tolerances of all components have been selected conservatively (to provide full benefit offered by the safety margins allowed in the manufacturers' ratings). Consequently, the shortest lived of these parts may be expected to operate longer than vacuum tubes.

4-46 SERVICE PROCEDURES

4-47. The procedure recommended for locating any source of deviation in the Model 301 is that applied in most electronic trouble shooting; i.e., the systematic measurement of DC plate voltage to reveal the anomalous stage, followed by critical examination of the circuitry in that stage to pinpoint the trouble source.

4-48. An oscilloscope is of inestimable value in trouble shooting precision electronic instruments, especially if the technician is familiar with the correct waveforms which appear at specific test points. To aid in such familiarization, normal waveform oscillograms are included in this manual (refer to paragraph 4-57).

4-49. As with any electronic equipment, oscilloscope analysis will reveal -- and aid in localizing -- any source of trouble, but it remains for the technician to pinpoint the actual component or connection at fault by means of voltage- and resistance-checks (and finally by means of substitution).

4-50. CHOPPER REPLACEMENT. Choppers are installed in standard 6-pin porcelain sockets. However, to

isolate the drive coil from the chopper contacts, drive voltage is applied through a 2-pin connector on the side of the chopper case. The mating connector on the drive-voltage line is removed by grasping it and pulling straight out from the chopper case.

4-51. TUBE REPLACEMENT. The tubes in the Model 301 are removed in a straightforward manner. Be sure that shields are properly installed on the correct tubes of the main circuit board assembly.

4-52 PART IDENTIFICATION

4-53. The etched board of the Model 301 is shown in Figures 4-5 and 4-6. It is illustrated from the back-----or etched -- side of the board, with components and their respective connections indicated as they would appear if the board were transparent. This will expedite location of any point on the board, especially if the schematic diagram is folded open to view in conjunction with this usage.

4-54. Assembly photographs in Figures 4-7 through 4-9 illustrate the locations of components in the cabinet model (Model 301). Figures 4-10 through 4-12 show the locations of components in the rackmount model (Model 301R). Where necessary, magnified insets are used to reveal the locations of otherwise hidden components.

4-55 MAINTENANCE SUPPORT DATA

4-56. Maintenance procedures for the Model 301 are supported by the inclusion of data such as waveform oscillograms, pertinent voltages, list of replaceable parts, and schematic diagrams.

4-57. WAVEFORMS. Figures 4-13 through 4-21 illustrate typical waveforms observable at pertinent points in the instrument. Possible deviation from an illustrated waveform---with regard to size---may stem from the use of an oscilloscope of different design, but waveforms will appear substantially as shown if no malfunction exists in the unit being tested. Signal amplitudes are implicitly shown by means of the noted oscilloscope settings. Each square on the dial scale represents one centimeter.

4-58. VOLTAGE MEASUREMENTS. Table 4-2 lists nominal voltages as measured to chassis ground from pertinent points in the Model 301. Note that certain AC voltages are tabulated as read from pin to pin of a tube, rather than from a tube pin to chassis ground.

4-59. PARTS LIST. Table 4-3 lists the replaceable parts of the Model 301 DC Voltage Standard and Nullmeter. Those parts which are recommended for stocking as spares are marked by an asterisk. The manufacturers are designated by code, and these tabulations may be decoded by reference to Table 4-4.

4-60. SCHEMATIC DIAGRAM. Figure 4-22 schematically illustrates the circuitry of the Model 301. As implied in earlier paragraphs, this drawing is printed on a page having sufficient apron to permit its use unfolded while referring to other points in the manual.

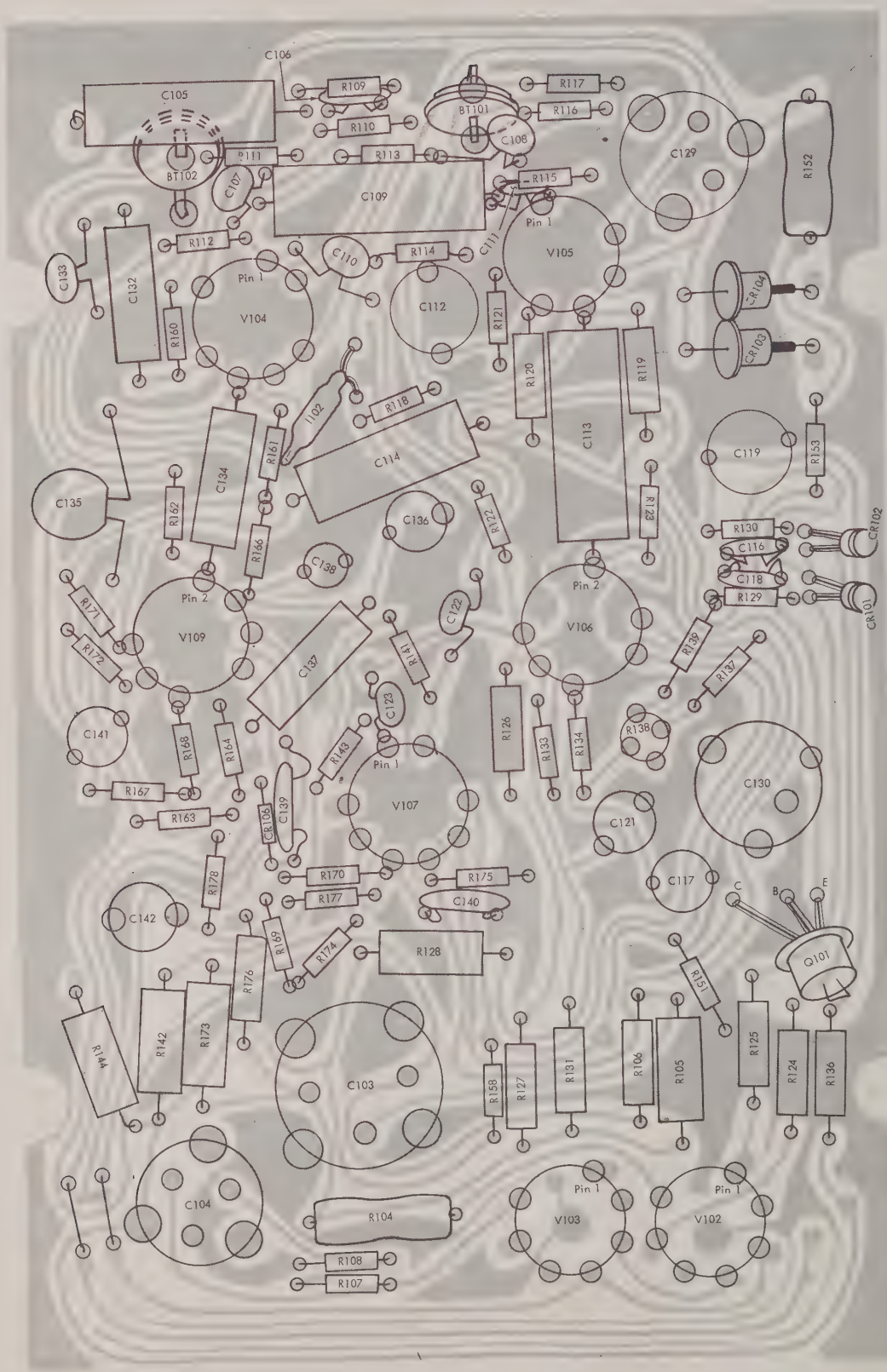


Figure 4-5. Etched-Board Component Locations Viewed from Etch Side (Early Production Units)

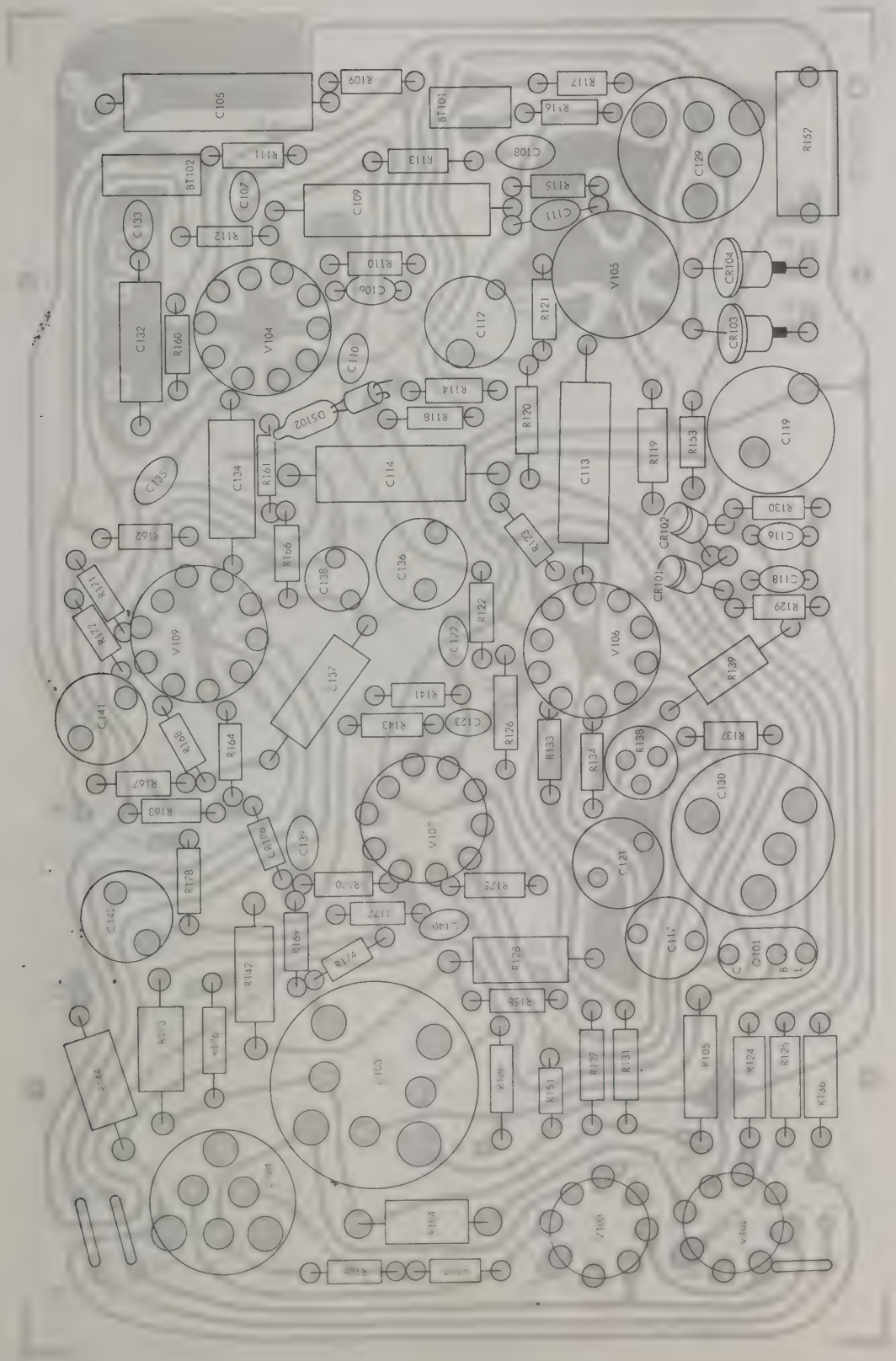


Figure 4-6. Etched-Board Component Locations Viewed from Etch Side (Late Production Units)

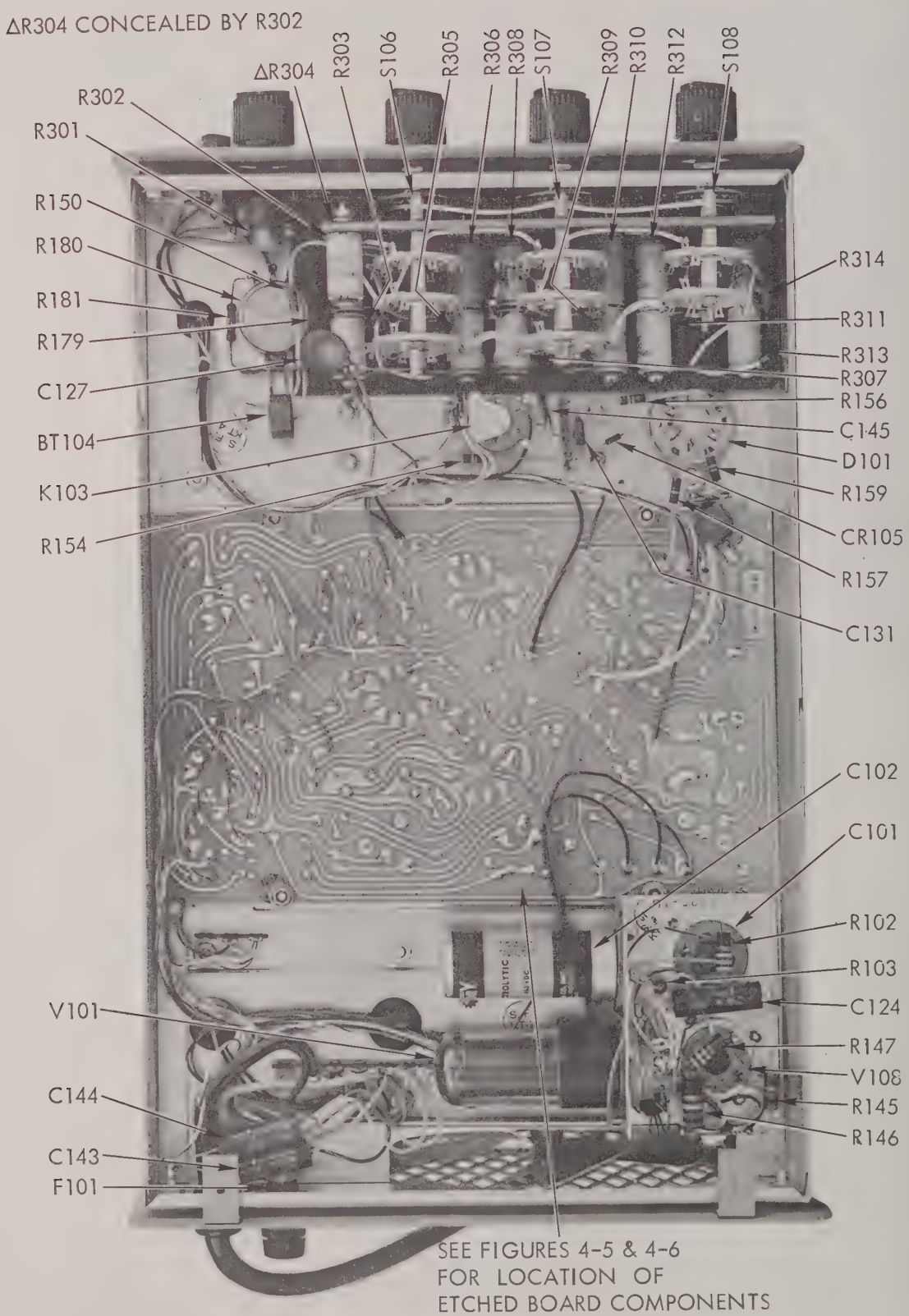


Figure 4-7. Model 301 (Left Side, Shield Removed) Showing Component Locations

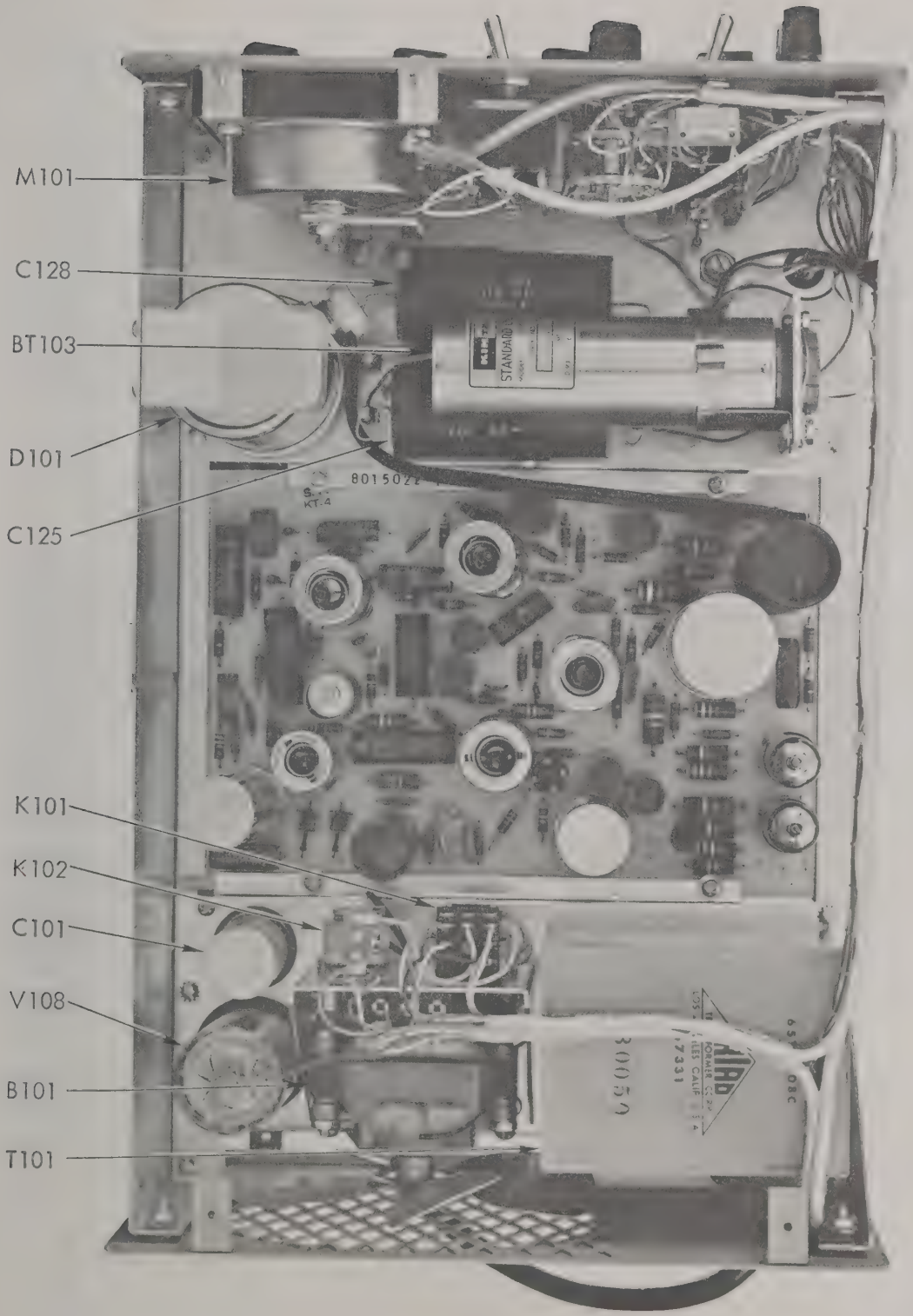


Figure 4-8. Model 301 (Right Side) Showing Component Locations

Figure 4-9. Model 301 (Right Side) Showing Additional Component Locations

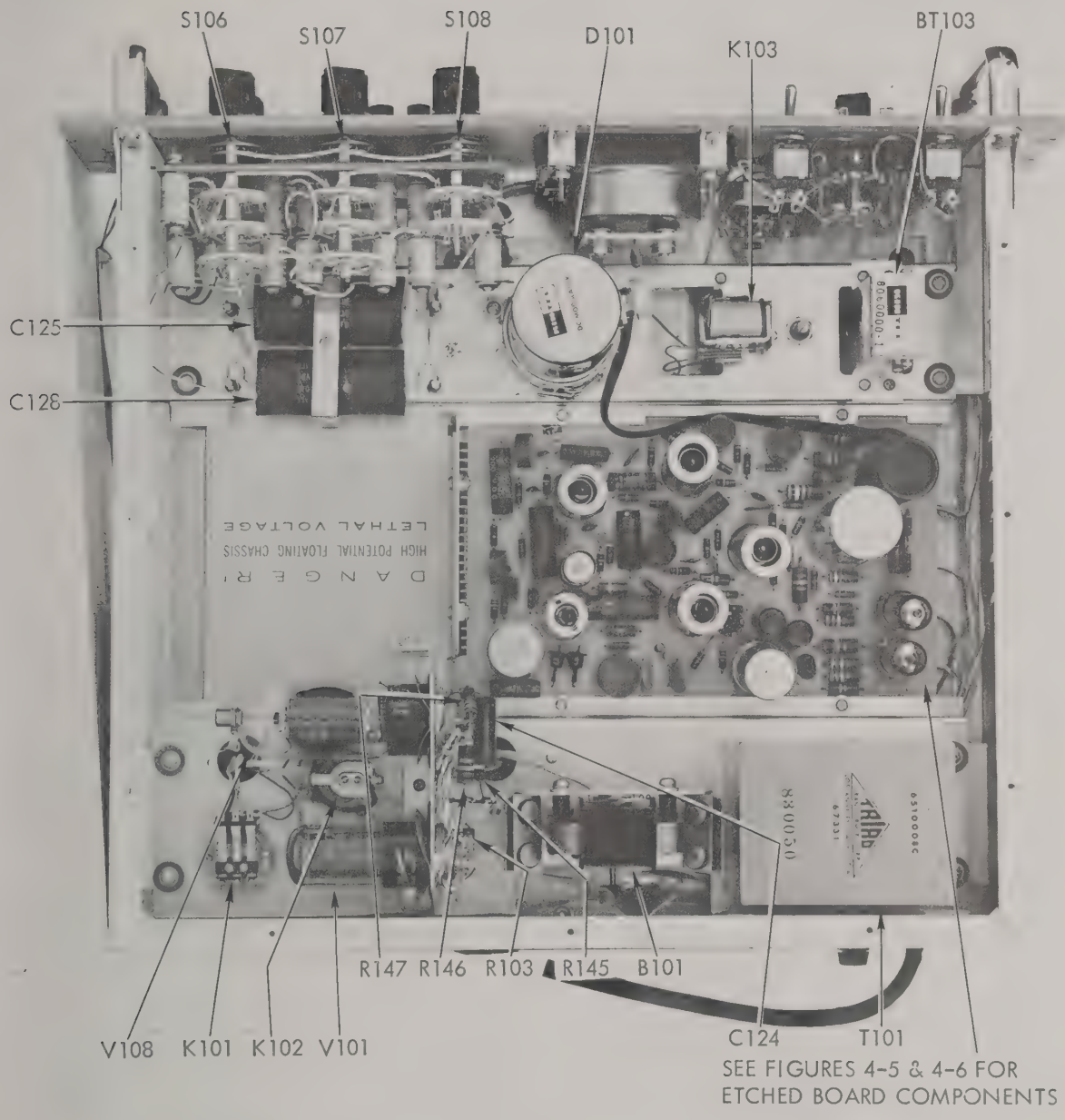


Figure 4-10. Model 301R (Top View), Showing Component Locations

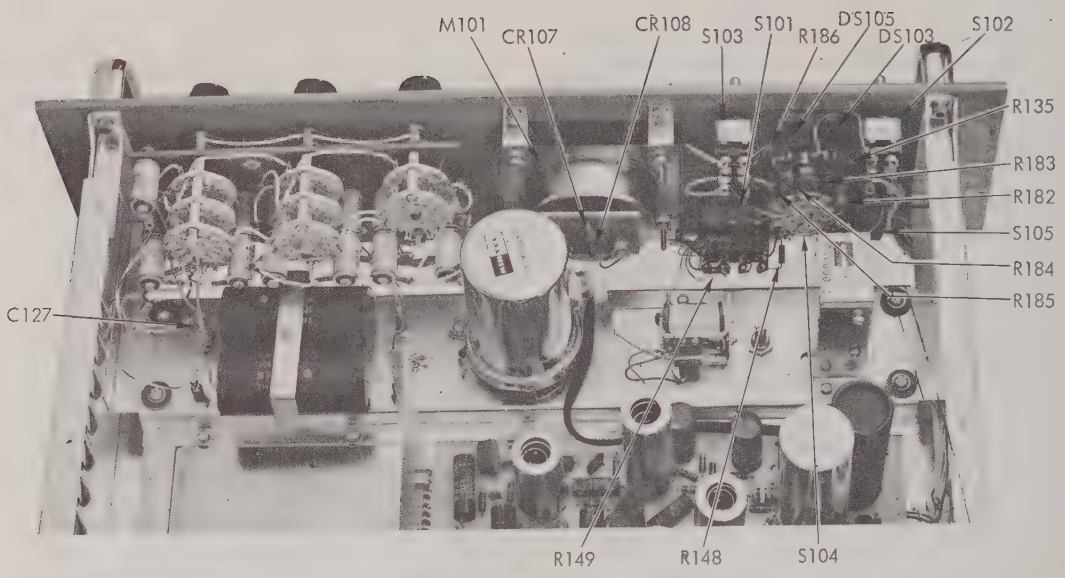


Figure 4-11. Model 301R (Top View), Showing Additional Component Locations

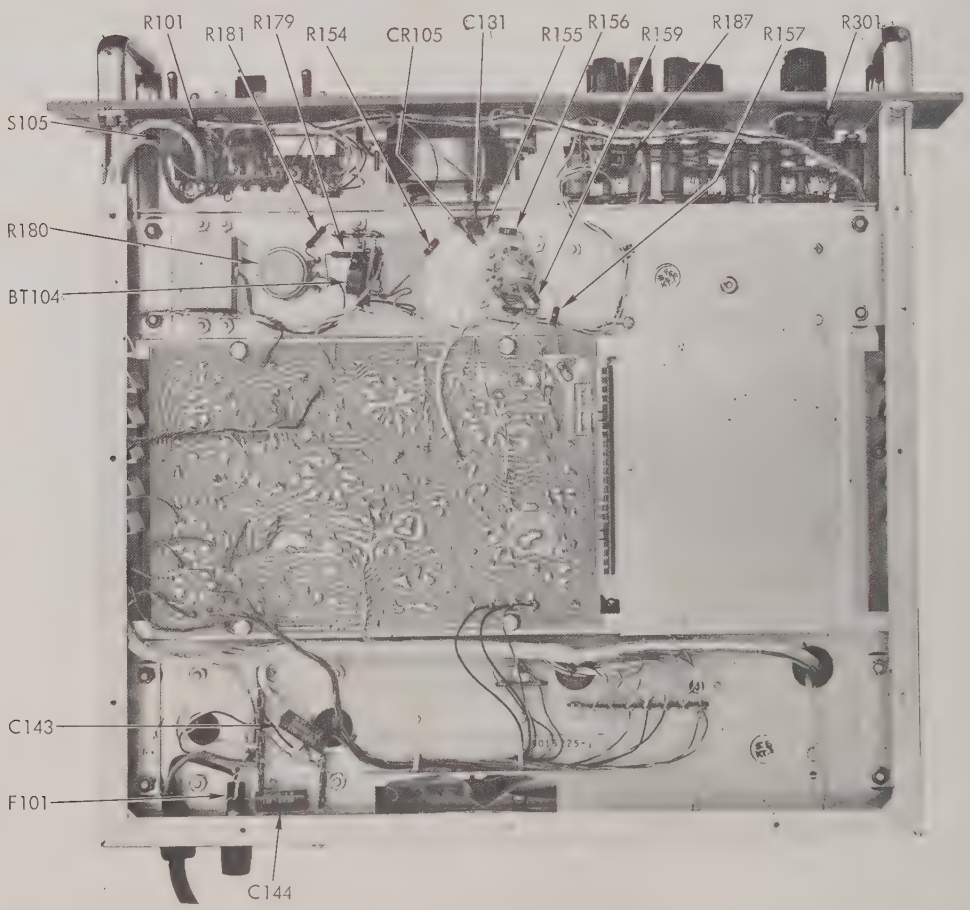
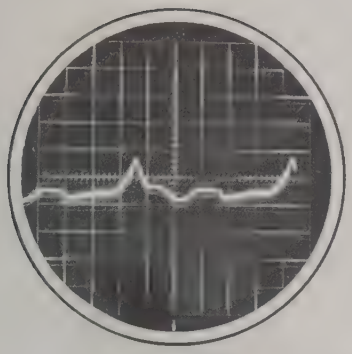


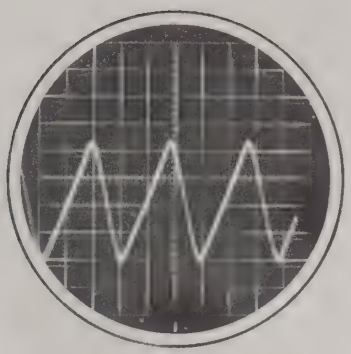
Figure 4-12. Model 301R (Bottom View, Shield Removed), Showing Component Locations



DC BALANCE MEASURED AT THE JUNCTION OF CR101/CR102

SENSITIVITY: 10 VOLTS PER CENTIMETER
SWEEP TIME: 2 MILLISECONDS

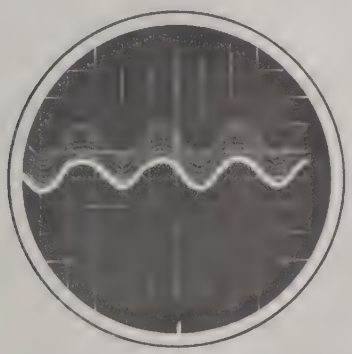
Figure 4-13



NORMAL RIPPLE MEASURED AT THE JUNCTION OF R104/C103A

SENSITIVITY: 1 VOLT PER CENTIMETER
SWEEP TIME: 2 MILLISECONDS

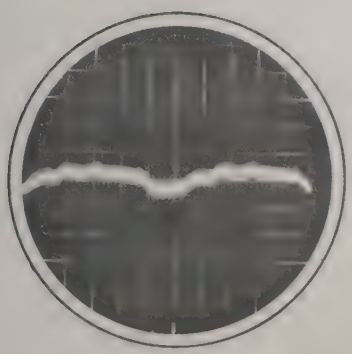
Figure 4-14



NORMAL RIPPLE MEASURED AT THE JUNCTION OF R105/R106/C103B

SENSITIVITY: 10 MV PER CENTIMETER
SWEEP TIME: 2 MILLISECONDS

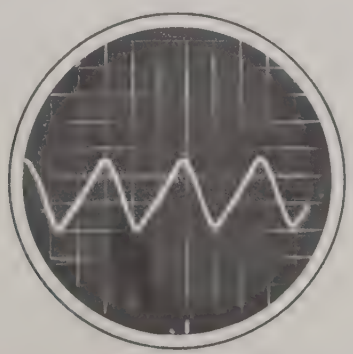
Figure 4-15



NORMAL RIPPLE MEASURED AT THE JUNCTION OF R106/C103C

SENSITIVITY: 2 MV PER CENTIMETER
SWEEP TIME: 2 MILLISECONDS

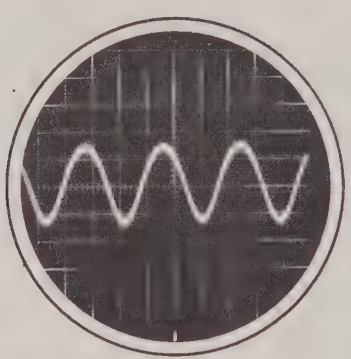
Figure 4-16



NORMAL RIPPLE MEASURED AT THE JUNCTION OF CR103/C129A (PIN 4 OF V105)

SENSITIVITY: .5 VOLTS PER CENTIMETER
SWEEP TIME: 2 MILLISECONDS

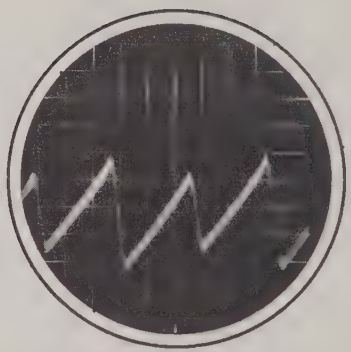
Figure 4-17



NORMAL RIPPLE MEASURED AT PIN 3 OF V105

SENSITIVITY: 20 MV PER CENTIMETER
SWEEP TIME: 2 MILLISECONDS

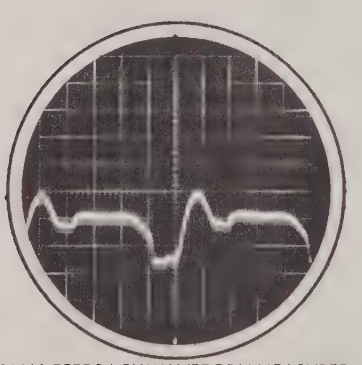
Figure 4-18



NORMAL RIPPLE MEASURED AT THE JUNCTION OF R102/R103

SENSITIVITY: .1 VOLT PER CENTIMETER
SWEEP TIME: 2 MILLISECONDS

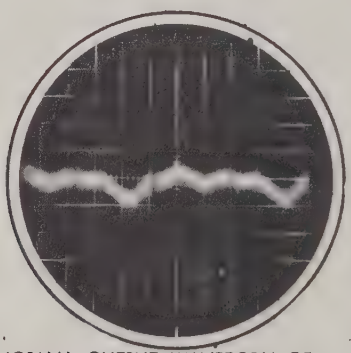
Figure 4-19



NORMAL FEEDBACK WAVEFORM MEASURED AT THE JUNCTION OF R159 C136

SENSITIVITY: .1 VOLT PER CENTIMETER
SWEEP TIME: 2 MILLISECONDS

Figure 4-20



NORMAL OUTPUT WAVEFORM OF AVERAGE INSTRUMENT HAVING AN APPROXIMATE 40 μv NOISE LEVEL

SENSITIVITY: 20 MV PER CENTIMETER
SWEEP TIME: 2 MILLISECONDS

NOTE: THIS MEASUREMENT OBTAINED THROUGH HP400D WHICH WAS SET IN THE .001 POSITION, AND CONNECTED TO THE OUTPUT TERMINALS OF THE MODEL 301 UNDER TEST

Figure 4-21.

NOTE: IN CHECKING AN INSTRUMENT AGAINST WAVEFORMS, RELAY K103 MUST BE CLOSED. IF PROTECTIVE CIRCUIT IS BREAKING CONTACT, K103 MAY BE HELD CLOSED MANUALLY UNTIL WAVEFORM IS MEASURED.

MEASUREMENTS MADE WITH HEWLETT-PACKARD HP130A OSCILLOSCOPE, WITH DIAL SCALE FULLY ILLUMINATED, AND WITH INTENSITY RESTRICTED AS MUCH AS POSSIBLE FOR CLARITY OF PHOTOGRAPH.

Table 4-2. Approximate Voltage Measurements, Model 301 DC Voltage Standard and Nullmeter

TUBE NUMBER	PIN 1	PIN 2	PIN 3	PIN 4	PIN 5	PIN 6	PIN 7	PIN 8	PIN 9
V101 5Y3	NC	+380V *5V AC	NP	-300V *540V AC	NP	-300V *540V AC	NP	+380V *5V AC	NP
V102 6X4	**330V AC	NC	*6.3V AC	*6.3V AC	NC	**330V AC	+380V	NP	NP
V103 6X4	-390V **440V AC	NC	*6.3V AC	*6.3V AC	NC	-530V **440V AC	+15V	NP	NP
V104 5751	+115V	-1.2V	0V	+5.5V	+5.5V	+115V	-1.2V	0V	0V HTR TAP
V105 6AU6	-1.3V	0V	+5.5V	+12V	+190V	+70V	0V	NP	NP
V106 6AU8	-240V	-250V	0V	-190V *6.3V AC	-190V *6.3V AC	-240V	-225V	-170V	-17V
V107 6AU8	-185V	-120V	0V	-190V *6.3V AC	-190V *6.3V AC	-0.16V	-0.9V	+44V	+150V
V108 6BG6	NC	*6.3V AC	+0.45V	NP	-18V	NP	*6.3V AC	+120V	+380V (PLATE CAP)
V109 6AW8	0V	-1.35V	+80V	0V *6.3V AC	0V *6.3V AC	0V	-1.3V	+24V	+155V

*AC VOLTAGE MEASURED FROM PIN OF SAME TUBE WHICH SHOWS SAME READING

**AC VOLTAGE MEASURED TO FLOATING CHASSIS

NC = NO CONNECTION

NP = NO PIN

ALL MEASUREMENTS MADE WITH OUTPUT SET AT 300V AND WITH POSITIVE OUTPUT TERMINAL STRAPPED TO FRONT PANEL

Table 4-3. List of Replacement Parts

CIRCUIT SYMBOL	DESCRIPTION	# MFR.	KIN TEL PART NO.
B101	MOTOR, ELECTRICAL, FAN, 115 VAC	KT	3107739
BT101	CELL, MERCURY, 1.35 VDC	KT	1810003-001
BT101	CELL, MERCURY, 1.35 VDC	KT	1810003-001
BT103	CELL, STANDARD, 1.35 VDC	KT	0200220
BT104	CELL, MERCURY, 1.35 VDC	KT	1810003-001
C101	CAPACITOR, FIXED, ELECTROLYTIC, 40 µf, 450 VDC	AST	0501124
C102	CAPACITOR, FIXED, ELECTROLYTIC, 40 µf, 450 VDC	AST	0501124
C103A/B/C	CAPACITOR, FIXED, ELECTROLYTIC, 20/4080 µf, 450VDC	MAL	0510022
C104A/B/C	CAPACITOR, FIXED, ELECTROLYTIC, 10/10/20 µf, 450 VDC	MAL	0510021
C105	CAPACITOR, FIXED, MYLAR DIELECTRIC, 0.1 µf, 200 VDC	GAL	0610017-027
C106	CAPACITOR, FIXED, CERAMIC DISC, 150 µµf, 500 VDC	CLB	0401025
C107	CAPACITOR, FIXED, CERAMIC DISC, 100 µµf, 500 VDC	CLB	0401022
C108[10]	CAPACITOR, FIXED, CERAMIC DISC, 0.003 µf, 500 VDC	ERI	0403741
C108[11]	CAPACITOR, FIXED, CERAMIC DISC, 0.0033 µf, 500 VDC	ERI	0401051
C109	CAPACITOR, FIXED, MYLAR DIELECTRIC, 0.1 µf, 400 VDC	GAL	0610018-027
C110	CAPACITOR, FIXED, CERAMIC DISC, 50 µµf, 500 VDC	CLB	0401016

Table 4-3. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	# MFR.	KIN TEL PART NO.
C111	CAPACITOR, FIXED, CERAMIC DISC, 100 μμf, 500 VDC	CLB	0401022
C112	CAPACITOR, FIXED, ELECTROLYTIC, 8 μf, 150 VDC	MAL	0510023-001
C113	CAPACITOR, FIXED, MYLAR DIELECTRIC, 0.047 μf, 600 VDC	GAL	0610019-023
C114	CAPACITOR, FIXED, MYLAR DIELECTRIC, 0.022 μf, 600 VDC	GAL	0610019-019
C116	CAPACITOR, FIXED, CERAMIC DISC, 0.01 μf, 500 VDC	CLB	0401056
C117	CAPACITOR, FIXED, EPOXY-CASED, 0.047 μf, 400 VDC	GAL	0610014-023
C118	CAPACITOR, FIXED, CERAMIC DISC, 0.01 μf, 500 VDC	CLB	0401056
C119	CAPACITOR, FIXED, EPOXY-CASED, 0.047 μf, 400 VDC	GAL	0610014-035
C120	CAPACITOR, FIXED, EPOXY-CASED, 0.047 μf, 400 VDC	GAL	0610014-035
C121	CAPACITOR, FIXED, EPOXY-CASED, 0.047 μf, 400 VDC	GAL	0610014-023
C122	CAPACITOR, FIXED, CERAMIC DISC, 0.001 μf, 500 VDC	CLB	0401046
C123	CAPACITOR, FIXED, CERAMIC DISC, 0.001 μf, 500 VDC	CLB	0401046
C124	CAPACITOR, FIXED, MYLAR DIELECTRIC, 0.1 μf, 200 VDC	GAL	0610017-027
[12]C125A/B	CAPACITOR, FIXED, MYLAR DIELECTRIC, 1 μf, 600 VDC	GAL	0810015-001
C127	CAPACITOR, FIXED, CERAMIC DISC, 0.01 μf, 500 VDC	CLB	0401056

Table 4-3. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	# MFR.	KIN TEL PART NO.
[12]C128 C125	CAPACITOR, FIXED, MYLAR DIELECTRIC, 1 µf, 600 VDC	GAL	0610019-039
C129A/B	CAPACITOR, FIXED, ELECTROLYTIC, 1000/1000 µf, 15 VDC	MAL	0510007
C130	CAPACITOR, FIXED, ELECTROLYTIC, 1000 µf, 6 VDC	MAL	0510024
C131	CAPACITOR, FIXED, CERAMIC DISC, 0.002 µf, 500 VDC	CLB	0401048
C132	CAPACITOR, FIXED, MYLAR DIELECTRIC, 0.01 µf, 200 VDC	GAL	0610017-015
C133	CAPACITOR, FIXED, CERAMIC DISC, 50 µµf, 500 VDC	CLB	0401016
C134	CAPACITOR, FIXED, MYLAR DIELECTRIC, 0.01 µf, 400 VDC	GAL	0610018-015
C135[10]	CAPACITOR, FIXED, CERAMIC DISC, 0.003 µf, 500 VDC	ERI	0403741
C135[11]	CAPACITOR, FIXED, CERAMIC DISC, 0.0033 µf, 500 VDC	ERI	0401051
C136	CAPACITOR, FIXED, EPOXY-CASED, 0.1 µf, 400 VDC	GAL	0610014-027
C137	CAPACITOR, FIXED, MYLAR DIELECTRIC, 0.01 µf, 400 VDC	GAL	0610018-015
C138	CAPACITOR, FIXED, EPOXY-CASED, 0.01 µf, 400 VDC	GAL	0610014-015
C139	CAPACITOR, FIXED, CERAMIC DISC, 0.02 µf, 500 VDC	CLB	0401058
C140	CAPACITOR, FIXED, CERAMIC DISC, 0.02 µf, 500 VDC	CLB	0401058
C141	CAPACITOR, FIXED, EPOXY-CASED, 0.1 µf, 400 VDC	GAL	0610014-027

Table 4-3. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	MFR.	KIN TEL PART NO.
C142	CAPACITOR, FIXED, EPOXY-CASED, 0.1 μf, 400 VDC	GAL	0610014-027
C143	CAPACITOR, FIXED, MYLAR DIELECTRIC, 0.01 μf, 600 VDC	GAL	0610019-015
C144	CAPACITOR, FIXED, MYLAR DIELECTRIC, 0.01 μf, 600 VDC	GAL	0610019-015
C145[1]	CAPACITOR, FIXED, CERAMIC DISC, 0.002 μf, 500 VDC	CLB	0401048
CR101	SEMICONDUCTOR DEVICE, DIODE, Type 3U1	INT	3506774-007
CR102	SEMICONDUCTOR DEVICE, DIODE, Type 3U1	INT	3506774-007
CR103	SEMICONDUCTOR DEVICE, DIODE, Type 1N91	GE	3506751-002
CR104	SEMICONDUCTOR DEVICE, DIODE, Type 1N91	GE	3506751-002
CR105	SEMICONDUCTOR DEVICE, DIODE, Type 1N626	HUG	3510006
CR106	SEMICONDUCTOR DEVICE, DIODE, Type 1N464	HUG	3510012
CR107[8]	SEMICONDUCTOR DEVICE, DIODE, Type 1N2090	MAL	3510028-001
CR108[8]	SEMICONDUCTOR DEVICE, DIODE, Type 1N2090	MAL	3510028-001
D101	CONVERTER, ELECTRO-MECHANICAL, Special	BRO	6310002
D101[2]	CONVERTER, ELECTRO-MECHANICAL, Type DCM-88A	KT	6310010-001
F101	FUSE, CARTRIDGE, 1.25 ampere, SLOBLO	LTF	1710040-021

Table 4-3. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	# MFR.	KIN TEL PART NO.
I101	LIGHT, INDICATOR, NEON, Type NE-2A	ELD	1710036-001
I102	LIGHT, INDICATOR, NEON, Type NE-2	GCM	1704151
I103	LIGHT, INDICATOR, NEON, Type NE-2A	ELD	1710036-001
I104	LIGHT, INDICATOR, NEON, Type NE-2A	ELD	1710036-001
I105	LIGHT, INDICATOR, NEON, Type NE-2A	ELD	1710036-001
K101	RELAY, ARMATURE, 5 amperes, Type MG-3C-115 VA	LEA	3710002
K102	RELAY, ARMATURE, SPDT 10KΩ, 2-32 VDC	LEA	3701285
K103[3]	RELAY, ARMATURE, SPDT, 10KΩ, 2-32 VDC	LEA	3701285
K103	RELAY, ARMATURE, SPDT, 14KΩ	CLR	3710021
M101	METER, PANEL, Special	KT	3010004
Q101	TRANSISTOR, Type 2N169	EIA	7210017-169
R101	RESISTOR, FIXED, COMPOSITION, 100K, 1/2W, 5%	AB	0310030-104
R101[2]	RESISTOR, FIXED, COMPOSITION, 100K, 1W, 5%	AB	0310031-104
R102	RESISTOR, FIXED, COMPOSITION, 330K, 1W, 5%	AB	0310031-334
R103	RESISTOR, FIXED, COMPOSITION, 330K, 1W, 5%	AB	0310031-334
R104	RESISTOR, FIXED, WIRE-WOUND, 500Ω, 5W, 10%	OHM	5110010-028

Table 4-3. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	# MFR.	KIN TEL PART NO.
R105	RESISTOR, FIXED, COMPOSITION, 10K, 2W, 5%	AB	0310032-103
R106	RESISTOR, FIXED, COMPOSITION, 39K, 1W, 5%	AB	0310031-393
R107	RESISTOR, FIXED, COMPOSITION, 470Ω, 1/2W, 5%	AB	0310030-471
R108	RESISTOR, FIXED, COMPOSITION, 470Ω, 1/2W, 5%	AB	0310030-471
R109	RESISTOR, FIXED, COMPOSITION, 1K, 1/2W, 5%	AB	0310030-102
R110	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	AB	0310030-105
R111	RESISTOR, FIXED, COMPOSITION, 10M, 1/2W, 5%	AB	0310030-106
R112	RESISTOR, FIXED, COMPOSITION, 220K, 1/2W, 5%	AB	0310030-224
R113	RESISTOR, FIXED, COMPOSITION, 5.6K, 1/2W, 5%	AB	0310030-562
R114	RESISTOR, FIXED, COMPOSITION, 470K, 1/2W, 5%	AB	0310030-474
R115	RESISTOR, FIXED, COMPOSITION, 1.5M, 1/2W, 5%	AB	0310030-155
R116	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	AB	0310030-105
R117	RESISTOR, FIXED, COMPOSITION, 330K, 1/2W, 5%	AB	0310030-334
R118	RESISTOR, FIXED, COMPOSITION, 4.7M, 1/2W, 5%	AB	0310030-475
R119	RESISTOR, FIXED, COMPOSITION, 82K, 1W, 5%	AB	0310031-823

Table 4-3. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	# MFR.	KIN TEL PART NO.
R120	RESISTOR, FIXED, COMPOSITION, 120K, 1W, 5%	AB	0310031-124
R121	RESISTOR, FIXED, COMPOSITION, 47K, 1/2W, 5%	AB	0310030-473
R122	RESISTOR, FIXED, COMPOSITION, 270K, 1/2W, 5%	AB	0310030-274
R123	RESISTOR, FIXED, COMPOSITION, 6.8M, 1/2W, 5%	AB	0310030-685
R124	RESISTOR, FIXED, COMPOSITION, 330K, 1W, 5%	AB	0310031-334
R125	RESISTOR, FIXED, COMPOSITION, 330K, 1W, 5%	AB	0310031-334
R126	RESISTOR, FIXED, COMPOSITION, 82K, 1W, 5%	AB	0310031-823
R127	RESISTOR, FIXED, COMPOSITION, 100K, 1W, 5%	AB	0310031-104
R128	RESISTOR, FIXED, COMPOSITION, 27K, 2W, 5%	AB	0310032-273
R129	RESISTOR, FIXED, COMPOSITION, 33K, 1/2W, 5%	AB	0310030-333
R130	RESISTOR, FIXED, COMPOSITION, 33K, 1/2W, 5%	AB	0310030-333
R131	RESISTOR, FIXED, COMPOSITION, 330K, 1W, 5%	AB	0310031-334
R133	RESISTOR, FIXED, COMPOSITION, 56K, 1/2W, 5%	AB	0310030-563
R134	RESISTOR, FIXED, COMPOSITION, 6.8M, 1/2W, 5%	AB	0310030-685
R135[2]	RESISTOR, FIXED, COMPOSITION, 100K, 1W, 5%	AB	0310031-104

Table 4-3. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	# MFR.	KIN TEL PART NO.
R136	RESISTOR, FIXED, COMPOSITION, 56K, 1W, 5%	AB	0310031-563
R137	RESISTOR, FIXED, COMPOSITION, 470K, 1/2W, 5%	AB	0310030-474
R138	RESISTOR, VARIABLE, COMPOSITION, 10K, 1/4W, 5%	AB	5010179-008
R139	RESISTOR, FIXED, COMPOSITION, 47K, 1/2W, 5%	AB	0310030-473
R141	RESISTOR, FIXED, COMPOSITION, 2.2M, 1/2W, 5%	AB	0310030-225
R142	RESISTOR, FIXED, COMPOSITION, 39K, 2W, 5%	AB	0310032-393
R143	RESISTOR, FIXED, COMPOSITION, 560Ω, 1/2W, 5%	AB	0310030-561
R144	RESISTOR, FIXED, COMPOSITION, 82K, 2W, 5%	AB	0310032-823
R145	RESISTOR, FIXED, COMPOSITION, 100Ω, 1W, 5%	AB	0310031-101
R146	RESISTOR, FIXED, COMPOSITION, 100K, 2W, 5%	AB	0310032-104
R146[4]	RESISTOR, FIXED, COMPOSITION, 82K, 2W, 5%	AB	0310032-823
R147	RESISTOR, FIXED, COMPOSITION, 39K, 1W, 5%	AB	0310031-393
R148	RESISTOR, FIXED, COMPOSITION, 100K, 1W, 5%	AB	0310031-104
R148[2]	RESISTOR, FIXED, COMPOSITION, 100K, 1/2W, 5%	AB	0310030-104
R149	RESISTOR, FIXED, COMPOSITION, 10Ω, 1/2W, 5%	AB	0310030-100

Table 4-3. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	# MFR.	KIN TEL PART NO.
R150	RESISTOR, FIXED, COMPOSITION, 220Ω, 1/2W, 5%	AB	0310030-221
R151	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	AB	0310030-105
R152	RESISTOR, FIXED, WIRE-WOUND, 4Ω, 5W, 10%	OHM	5110010-005
R153	RESISTOR, FIXED, COMPOSITION, 82Ω, 1/2W, 5%	AB	0310030-820
R154	RESISTOR, FIXED, COMPOSITION, 220K, 1/2W, 5%	AB	0310030-224
R155	RESISTOR, FIXED, COMPOSITION, 330K, 1/2W, 5%	AB	0310030-334
R156	RESISTOR, FIXED, COMPOSITION, 22K, 1/2W, 5%	AB	0310030-223
R157	RESISTOR, FIXED, COMPOSITION, 1K, 1/2W, 5%	AB	0310030-102
R158	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	AB	0310030-105
R159	RESISTOR, FIXED, COMPOSITION, 22K, 1/2W, 5%	AB	0310030-223
R160	RESISTOR, FIXED, COMPOSITION, 10M, 1/2W, 5%	AB	0310030-106
R161	RESISTOR, FIXED, COMPOSITION, 220K, 1/2W, 5%	AB	0310030-224
R162	RESISTOR, FIXED, COMPOSITION, 3.3M, 1/2W, 5%	AB	0310030-335
R163	RESISTOR, FIXED, COMPOSITION, 10M, 1/2W, 5%	AB	0310030-106
R164	RESISTOR, FIXED, COMPOSITION, 100K, 1/2W, 5%	AB	0310030-104

Table 4-3. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	# MFR.	KIN TEL PART NO.
R166	RESISTOR, FIXED, COMPOSITION, 220K, 1/2W, 5%	AB	0310030-224
R167	RESISTOR, FIXED, COMPOSITION, 3.3M, 1/2W, 5%	AB	0310030-335
R168	RESISTOR, FIXED, COMPOSITION, 3.3M, 1/2W, 5%	AB	0310030-335
R169	RESISTOR, FIXED, COMPOSITION, 10M, 1/2W, 5%	AB	0310030-106
R170	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	AB	0310030-105
R171	RESISTOR, FIXED, COMPOSITION, 220K, 1/2W, 5%	AB	0310030-224
R172	RESISTOR, FIXED, COMPOSITION, 3.3M, 1/2W, 5%	AB	0310030-335
R173	RESISTOR, FIXED, COMPOSITION, 82K, 2W, 5%	AB	0310032-823
R174	RESISTOR, FIXED, COMPOSITION, 15K, 1/2W, 5%	AB	0310030-153
R175	RESISTOR, FIXED, COMPOSITION, 5.6K, 1/2W, 5%	AB	0310030-562
R176	RESISTOR, FIXED, COMPOSITION, 82K, 2W, 5%	AB	0310032-823
R177	RESISTOR, FIXED, COMPOSITION, 10M, 1/2W, 5%	AB	0310030-106
R178	RESISTOR, FIXED, COMPOSITION, 470Ω, 1/2W, 5%	AB	0310030-471
R179	RESISTOR, FIXED, DEPOSITED CARBON, 10K, 1/2W, 1%	TEX	4810011-028
R180	RESISTOR, VARIABLE, COMPOSITION, 5K, 2W, 5%	AB	5010053-007

Table 4-3. List of Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	KIN TEL PART NO.
R181	RESISTOR, FIXED, DEPOSITED CARBON, 800K, 1/2W, 1%	4810011-102
R182	RESISTOR, FIXED, DEPOSITED CARBON, 18M, 1W, 1%	4803544
R183	RESISTOR, FIXED, DEPOSITED CARBON, 1.8M, 1/2W, 1%	4810011-125
R184	RESISTOR, FIXED, DEPOSITED CARBON, 180K, 1/2W, 0.5%	4705395
R185	RESISTOR, FIXED, DEPOSITED CARBON, 18K, 1/2W, 1%	4810011-032
R186[2]	RESISTOR, FIXED, COMPOSITION, 100K, 1/2W, 5%	0310030-104
R187[5]	RESISTOR, FIXED, COMPOSITION, 560K, 1W, 5%	0310031-564
R301	RESISTOR, VARIABLE, WIRE-WOUND, 1K, +2, -0%, precision	5010062
R302	RESISTOR, FIXED, WIRE-WOUND, 1K, 1W, 0.1%	5204364
R303	RESISTOR, FIXED, WIRE-WOUND, 1K, 1W, 0.1%	5204364
R304	RESISTOR, FIXED, WIRE-WOUND, 2K, 1W, 0.1%	5204367
R305	RESISTOR, FIXED, WIRE-WOUND, 2K, 1W, 0.1%	5204367
R306	RESISTOR, FIXED, WIRE-WOUND, 4K, 1W, 0.1%	5204368
R307	RESISTOR, FIXED, WIRE-WOUND, 10K, 1W, 0.1%	5204372
R308	RESISTOR, FIXED, WIRE-WOUND, 20K, 1W, 0.1%	5204374

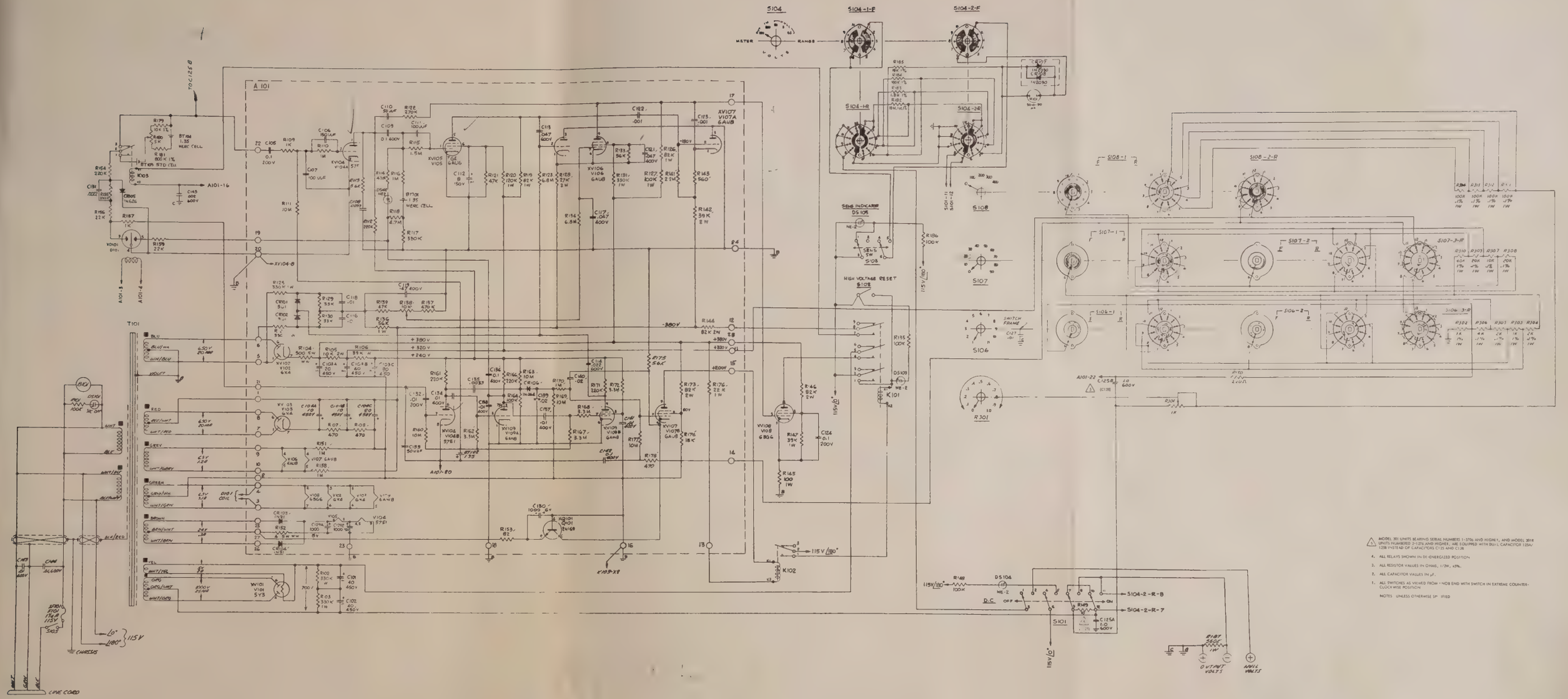
Table 4-3. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	# MFR.	KIN TEL PART NO.
R309	RESISTOR, FIXED, WIRE-WOUND, 20K, 1W, 0.1%	CIN	5204374
R310	RESISTOR, FIXED, WIRE-WOUND, 40K, 1W, 0.1%	CIN	5204377
R311	RESISTOR, FIXED, WIRE-WOUND, 100K, 1W, 0.1%	CIN	5204384
R312	RESISTOR, FIXED, WIRE-WOUND, 100K, 1W, 0.1%	CIN	5204384
R313	RESISTOR, FIXED, WIRE-WOUND, 100K, 1W, 0.1%	CIN	5204384
R314	RESISTOR, FIXED, WIRE-WOUND, 100K, 1W, 0.1%	CIN	5204384
S101	SWITCH, TOGGLE, 4PDT, Type MS25068-3	CUT	0310018-002
S102	SWITCH, TOGGLE, MOMENTARY, DPDT	CAR	6110004
S103	SWITCH, TOGGLE, MOMENTARY, DPDT	CAR	6110004
S104	SWITCH, SLIDE, SPDT	WIR	6110009
S105	SWITCH, TOGGLE, SPST	SMI	6103563
S106	SWITCH, ROTARY, SP10T, 3 decks, Type PA-O	CLB	6210014-001
S107	SWITCH, ROTARY, SP10T, 3 decks, Type PA-O	CLB	6210014-001
S108	SWITCH, ROTARY, SP5T, 2 decks, Type PA-O	CLB	6210014-001
T101[7]	TRANSFORMER, POWER, Special	KT	6510008
T101[6]	TRANSFORMER, POWER, Special	KT	6510027

Table 4-3. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	# MFR.	KIN TEL PART NO.
T101[9]	TRANSFORMER, POWER, Special	KT	6510092
V101	TUBE, ELECTRONIC, Type 5Y3GT	EIA	7002726
V102	TUBE, ELECTRONIC, Type 6X4	EIA	7002786
V103	TUBE, ELECTRONIC, Type 6X4	EIA	7002786
V104	TUBE, ELECTRONIC, Type 5751	EIA	7302812
V105	TUBE, ELECTRONIC, Type 6AU6	EIA	7002748
*V105	TUBE, ELECTRONIC, Type 6AU6	EIA	7010041-001
V106	TUBE, ELECTRONIC, Type 6AU8	EIA	7007118
V107	TUBE, ELECTRONIC, Type 6AU8	EIA	7007118
V108	TUBE, ELECTRONIC, Type 6BG6G	EIA	7002759
V109	TUBE, ELECTRONIC, Type 6AW8	EIA	7007419

*Replacement (GE only - use in preference to all others)
[1]Model 301 units serially numbered 3003 and higher; Model 301R units serially numbered 1066 and higher.
[2]Model 301 units serially numbered 3266 and higher; Model 301R units serially numbered 1056 and higher.
[3]Model 301 units serially numbered 3486 and higher; Model 301R units serially numbered 1196 and higher.
[4]Model 301 units serially numbered 3266 and higher; Model 301R units serially numbered 1046 and higher.
[5]Model 301 units serially numbered 3226 and on; Model 301R units serially numbered 1026 and on.
[6]Used only in Model 301R units prior to serial number 1096.
[7]Used in Model 301 units serially numbered prior to 3636 and 301R units 1096 and higher.
[8]Replacing obsoleted diode 1N1560.
[9]Used in Model 301 units serially numbered 3636 and higher.
[10]Used in Model 301 units serially numbered prior to 3661, Model 301R prior to 1246.
[11]Used in Model 301 units serially numbered 3661 and higher; Model 301R 1246 and higher.
[12]C125A/B replaces C125 and C128 in Model 301 units serially numbered 1-3706 and higher, and Model 301R units numbered 2-1276 and higher.



△ MODEL 301 UNITS BEARING SERIAL NUMBERS 1-370u AND HIGHER, AND MODEL 301R UNITS NUMBERED 2-127B AND HIGHER, ARE EQUIPPED WITH DUAL CAPACITOR 125A/125B INSTEAD OF CAPACITORS C125 AND C126.

4. ALL RELAYS SHOWN IN DE-ENERGIZED POSITION.
3. ALL RESISTOR VALUES IN OHMS, 1/2W, ±5%.
2. ALL CAPACITOR VALUES IN μF.
1. ALL SWITCHES AS VIEWED FROM KNOB END WITH SWITCH IN EXTREME COUNTER-CLOCKWISE POSITION.

NOTES UNLESS OTHERWISE SPECIFIED

Figure 4-22. Schematic Diagram, Models 301 and 301R DC Voltage Standard (Dwg. No. J8015100Z)

Recommended Spare Parts for KIN TEL Models 301, 301R and 302 DC Voltage Standard

KIN TEL PART NO.	DESCRIPTION	KIT NUMBER 8015-PK001 STOCK LEVEL 1 unit	KIT NUMBER 8015-PK005 STOCK LEVEL 5 units	KIT NUMBER 8015-PK025 STOCK LEVEL 25 units
0200220-001 or 8060000-001	Cell, standard	0	0	1
0501124	Capacitor, Electro Can, 40 µf, 450V	1	1	2
0510007	Capacitor, (A/B), 1000/1000 µf, 15V	0	1	1
0510021	Capacitor, (A/B/C), 10/10/20 µf, 450V	1	1	2
0510022	Capacitor, (A/B/C) 20/40/80 µf, 450V	1	1	2
0510023-001	Capacitor, 8 µf, 150V	1	1	2
0510024	Capacitor, 1000 µf, 6V	0	1	1
1710036-001	Indicator Light	0	1	1
1810003-001	Cell, Mercury, 1.35V	2	4	8
3010004	Meter, 25-0-25 µa	0	0	1
3107739	Fan Motor	0	0	1
3506751-002	Diode, 1N91	0	2	2
3506774-007	Diode, 3U1	0	2	2
3510012	Diode, 1N464	0	1	1
3510006	Diode, 1N626	0	1	1
3510028-001	Diode, 1N2090/T50	2	4	8
6110004	Switch, DPDT Momentary	0	1	1

Recommended Spare Parts for KIN TEL
Models 301, 301R, and 302 DC Voltage Standard (Contd)

KIN TEL PART NO.	DESCRIPTION	KIT NUMBER		
		1 unit	5 units	25 units
6310017	Converter, (Chopper), 60 cycle	0	1	1
6510092	Transformer, Power	0	0	1
7002726	Tube, Type 5Y3GT	1	2	4
7002748	Tube, Type 6AU6	1	2	4
7002759	Tube, Type 6BG6G	1	2	4
7002786	Tube, Type 6X4	2	4	8
7007118	Tube, Type 6AU8	2	4	8
7007419	Tube, Type 6AW8	1	2	5
7210017-169	Transistor, GE 2N169	0	0	1
7302812	Tube, Type 5751 (GE only)	1	2	5
5010062	Potentiometer, 1K	0	1	2

WARRANTY

COHU ELECTRONICS, INC., Kin Tel Division, warrants equipment manufactured to be free from defects of material and workmanship. Any part or parts will be repaired or replaced when proven by COHU examination to have been defective within one year (90 days for batteries, fuses, transistors and tubes) from date of shipment to the original purchaser. All warranty repairs will be performed at the factory or as otherwise authorized by COHU in writing. Transportation charges shall be prepaid by purchaser.

This warranty does not extend to COHU equipment subjected to misuse, accident, neglect or improper application; nor repaired or altered by other than COHU or those authorized by COHU in writing.

This warranty is in lieu of all other warranties express or implied. COHU shall not be liable for collateral or consequential damages.

For customer convenience, service departments are maintained throughout the United States by COHU Field Engineering Representatives.

COHU
ELECTRONICS, INC
KIN TEL DIVISION

FORM NO. S-212 (May 1, 1962)

5725 Kearny Villa Road
San Diego 12, California